Tenandra Scheme Modernisation Project Final Report

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Chairman's Foreword

The Tenandra Scheme Modernisation Project was funded by the Australian Government through the *Sustainable Rural Water Use and Infrastructure Program*.

This project has improved the long-term viability of the Scheme, thereby providing a sustainable future for its members; it has delivered a 10% improvement in water delivery efficiency; and it has returned 12,504 ML of water entitlements to the Commonwealth to aid the environment.

The Modernisation Project included a major rationalisation of the previous scheme into two shorter and more efficient channels. Twentyone kilometres of new link channel were constructed to link the shortened channels to the river, and to merge with the existing Greenhide Joint Water Share Scheme channel. The 12 km of the Greenhide channel and 13 km of the link channel were clay lined. About 60 km of former channel was decommissioned and rehabilitated, with eight former irrigation farms opting to leave the Scheme.

The efficiency of the remaining channel network has been significantly improved by clay-lining leaky sections of existing channel; the installation of two new pumping stations equipped with variable frequency drives and power correction devices to save electricity; and the installation of an automated system of channel regulators and offtake gates.

The longterm viability of the scheme for continuing members was secured by the creation of a 'Loss Account' to ensure efficient delivery of water held by remaining members.

The Modernisation Project has also provided a direct contribution to the local and regional economy, with a number of local businesses successfully tendering to provide professional and construction services. The scope of the project has enabled these businesses to increase their overall capability and the range of services offered.

The Board endorses this final report, marking another milestone in the 42-year history of the Tenandra Scheme.

Angus O'Brien
Chairman
Tenandra Scheme

1.0 Executive summary

The majority of water diverted to off-river irrigation schemes in the Murray Darling Basin flow through unlined earthen channels. While these structures are relatively cheap to build and operate, they have high water losses due to evaporation and seepage.

Analysis of water delivery data over the past 20 years indicates the average delivery efficiency of 10 schemes operating along the Murray Darling is about 80%. The most efficient of these schemes has a water delivery efficiency of about 90%, but only in years of high delivery.

The Tenandra Scheme (the Scheme) has been operating in the Macquarie Valley, NSW, since 1973. Prior to modernisation, it pumped water from the Macquarie River at the Gin Gin Weir, 18 km north-east of Trangie, to Haddon Rig station, 25 km north of Warren, via 85 km of main channel and 15 km of branch channels.

The Scheme held water entitlements to deliver 28,056 ML of General Security and 1,263 ML of Supplementary water to about 8,000 hectares of irrigable land across 22 properties belonging to 17 farming enterprises. The irrigable areas on each property ranged from 40 to 1,300 ha, with individual water entitlements ranging from 306 to 3,978 ML.

Water usage records for the 20 years to 2006/07 shows between 10% and 43% of water diverted to the Scheme was lost due to seepage and evaporation, with the highest losses reported during years of low allocation. The average loss was 5,400 ML per year, representing 20.5% of water pumped.

In November 2009, Nejuru Pty Ltd, an incorporated company owned by the Tenandra Scheme, submitted an application for funding from the Australian Government via the Private Irrigation Infrastructure Operators Program in New South Wales (PIIOP).

The objectives of the proposed Modernisation Project focused on four key areas:

- Improved water delivery efficiency by restructuring the Scheme into two shorter channels, re-routing the leakiest section of the main channel, clay-lining leaky sections of existing channels and decommissioning sections of the original Scheme.

- Improved water delivery infrastructure, including regulators, offtakes, flow meters, automated gates and telemetry.

- Improved water delivery, storage and utilisation on three large farms on the Scheme.

- Improved long-term viability of the Scheme through the creation of a ‘Loss Account’ to offset transmission losses of continuing scheme users.

The success of the Modernisation Project hinged on the creation of an innovative rationalisation program that enabled those members who wished to exit the Scheme to sell some or part of their water entitlements without affecting the viability of the Scheme for the remaining members.

In April 2010, the Australian Government approved funding of $37,475,140.

The Tenandra Scheme Modernisation Project has achieved a number of significant benefits for the Australian Government, Scheme members and the Lower Macquarie Valley, most notably being the return of 12,504 ML of water entitlements to the Australian Government via:

- a share of forecast improvements in water deliver efficiency (2,793 ML);
- a share of forecast improvements in on-farm efficiency (486 ML) and,
- a share of rationalised water entitlements (9,225 ML).

This project has established a new paradigm in water efficiency for open, earthen channels by reconfiguring an 85 km channel system with an average delivery length of 56.5 km into two sections, each with an average delivery length of 24.8 km. At the same time, the original water entitlement ratio of 296 ML/km has been reduced to 213 ML/km. These figures will improve as more water is transferred into the upgraded Scheme.

Water balance analysis shows the reconfigured channel achieved a water efficiency of 93% during its first two seasons (2013/14 and 2014/15), compared to 80% in 2012/13 when a similar amount of water was delivered. The creation and strategic use of the ‘Loss Account’ will further improve the viability of the Scheme and its users.

The improved efficiency of the Tenandra Scheme will significantly improve the long-term profitability and sustainability for the remaining Members, as well as providing significant flow-on economic benefits for the wider community.

2.0 Background

2.1 Overview of the Tenandra Scheme

The Tenandra Scheme has been operating in the Lower Macquarie Valley north-east of Warren since 1973. Before its modernisation, the Scheme pumped water from the Macquarie River at the Gin Gin Weir, 18 km north-east of Trangie, to Haddon Rig station, 25 km north of Warren via 85 km of main channel and 15 km of branch channels.

The Scheme held 28,056 ML of general security licence and 1,263 ML of supplementary licence on behalf of 17 farming enterprises that irrigated up to 8,000 hectares of land across 22 properties. These properties typically ranged from 1,000 ha to 5,500 ha in size, with one exceeding 23,000 ha. The irrigable areas on each farm ranged from 40 to 1,300 ha, with water entitlements ranging from 306 to 3,978 ML.

The region's self-mulching clay soils are suitable for irrigating summer crops (e.g. cotton, sorghum and corn) and annual winter crops (e.g. wheat, barley, canola and chickpeas). These soils are unsuitable for irrigating perennial tree crops due to their susceptibility to water logging. However, most farms along the Scheme have access to smaller areas of well-drained red soils that are suitable for drip irrigating a variety of horticultural crops.

2.2 Modernisation plan

Many of Australia's river systems, including the Macquarie River, are under stress from prolonged drought and the impact of climate change. Low water allocations meant the Tenandra Scheme did not operate in 2007, 2008 and 2009.

These issues, combined with known inefficiencies of water delivery (particularly during low allocation years), the pending introduction of water trading and the potential impact of new river operation rules, posed serious challenges to the long-term viability of the Scheme. The exit of any members would increase operating and maintenance costs for the remaining members, placing further pressure on the viability of the Scheme. Conversely, the closure of the Scheme would have serious economic and social consequences in the nearby towns of Warren and Trangie.

In November 2007, the Scheme successfully applied for $120,000 funding under the Australian Government's Irrigation Modernisation Planning Assistance Program. An additional $30,000 in funding was provided by the Scheme. The combined funding was used to investigate a range of options to reduce water losses and increase the delivery efficiency of the Scheme, particularly during periods of low allocation.

The first phase of this project examined physical, operational, financial, legal, economic and social perspectives of the Scheme. The second phase of the project examined options to reduce water delivery losses and the estimated water savings, capital costs, operational costs and economic benefits of these options. The third phase of the project involved the preparation of a detailed plan for the preferred option, including surveys, design and estimated costs.

This project, undertaken by Sustainable Soils Management Pty Ltd in association with Aquatech Consulting Pty Ltd, highlighted the inefficiency of water delivery using the Scheme's existing infrastructure. Water usage records for the 20 years to 2006/07 showed an average of 5,400 ML was lost from the Scheme each year. Expressed as a percentage of water delivered vs. water pumped, annual losses averaged 20.5% and ranged between 10% and 43%, with the highest losses reported in years of low allocation.

The Board presented 10 options for modernising the Scheme to its members in July 2008. Twenty irrigators, representing 82% of all water entitlements along the Scheme, elected to examine two options in greater detail:

- Option 4, which involved clay-lining selected sections of the existing main and branch channels to restrict seepage. This option was estimated to produce water savings of 1,810 ML per year (assuming 100% allocation).

- Option 9, which involved splitting the Scheme into two shorter and more efficient channels (i.e. the 'Top Scheme' and the 'Bottom Scheme') and reconfiguring the infrastructure of both channels. This option was estimated to produce water savings of 1,860 ML per year (assuming 100% allocation).

In October 2008, a confidential survey explored the current and future irrigation intentions of all Scheme members. Nine members indicated they would continue to irrigate if the Scheme was modernised. Eight members indicated they would most likely sell their entitlements totalling 8,278 ML, although six of these still wanted the opportunity to irrigate using temporary licences.

In April 2009, the Scheme members approved the development of a more detailed plan for Option 9, as it was felt that Option 4 did not address the core problem of improving water delivery efficiency, particularly during years of low allocation.

In November 2009, the Scheme committee presented a revised Modernisation Plan to members representing 92.5% of voting rights. This plan was slightly different to the original Option 9 in that it incorporated the existing Greenhide Joint Water Supply Scheme (refer to Section 3.4) into the Top Scheme to achieve even greater delivery efficiency and rationalisation of existing infrastructure.

This plan also included sub-projects to improve on-farm water efficiency on three large farms, the rationalisation of existing entitlements in the decommissioned central section and the return of 12,504 ML of water entitlements to the Australian Government. This option was unanimously accepted by attending members.

2.3 Hotspots Project

The Irrigation Infrastructure Hotspots Assessment Project was a compulsory component of the planning process. It used a consistent and science-based approach to identify the nature, location and amount of water losses (i.e. 'hotspots') in existing channel and piped irrigation systems across Australia.

In March 2009, Hyder Consulting Pty Ltd undertook a Hotspots Desktop Analysis and Design for the Tenandra Scheme. A water balance contained in this report estimated between 16% and 27% of total annual water use was lost due to seepage, leakage and unaccounted losses, most likely due to metering inaccuracy.

This report offered little insight into the operation and planned modernisation of the Scheme and was not considered further in the planning process.

2.4 PIIOP Proposal

2.4.1 Program objectives

In November 2009, Nejuru Pty Ltd submitted an application for funding from the Australian Government via the Private Irrigation Infrastructure Operators Program in New South Wales.

The objectives of the proposed Tenandra Scheme Modernisation Program were:

- To continue to provide irrigation opportunities on properties located off the Macquarie River.
- To provide a modern delivery system capable of efficiently delivering lower volumes of water that may result from reduced water allocations associated with climate change or predicted changes to river use.
- To ensure that water is used efficiently once delivered to farms.
- To provide a viable irrigation scheme and community.

The final plan focused on three key areas:

1. Water delivery reconfiguration and restructure:

- restructuring the Scheme into two shorter sub-schemes.
- re-routing the leakiest section of the main channel.
- decommissioning sections of the original Scheme.
- creation of a 'Loss Account' (for more details, refer to section 2.4.2.3).

2. Water delivery system upgrades:

- clay-lining leaky sections of existing channels to reduce seepage losses.
- installing new channel control structures.

3. Improvements to on-farm efficiency:

- modernising water delivery, storage and irrigation efficiency of three large Scheme members.

2.4.2 Planned works

2.4.2.1 Top Scheme

The application included provision for the rationalisation of the Top Scheme main channel to become 43 km long, with a revised 7,450 ML entitlement supplying eight properties (Figure 1). Specific components included:

- Incorporation of the Greenhide Joint Water Sharing Scheme channel and infrastructure into the first 12 km of the Top Scheme.

- Installation of additional pumps at the existing Greenhide pump station.

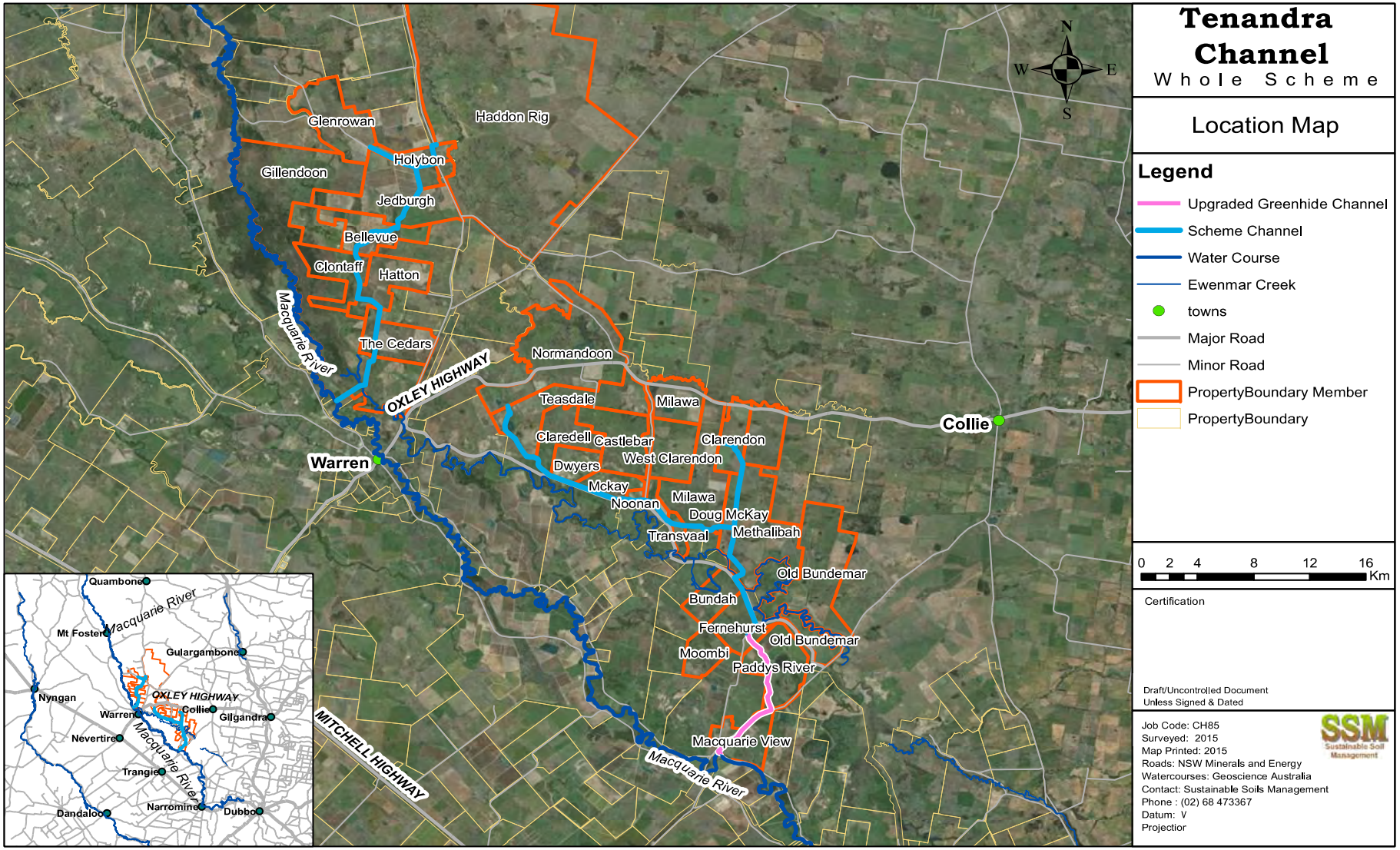
- Construction of 9 km of new channel to link the Greenhide channel with the existing Tenandra channel about 32 km downstream of the existing Tenandra pump site, and a further 5 km of new channel to link into the Milawa branch channel.

- Lining 22.4 km of new and existing channel with compacted, moisture-conditioned natural clay to minimise seepage.

- Decommissioning approximately 32 km of main channel and 8 km of branch channel.

It was estimated these projects would achieve 906 ML of water savings (assuming 100% allocation).

Figure 1: Location map of Tenandra Channel



2.4.2.2 Bottom Scheme

The application included provision for rationalisation of the Bottom Scheme main channel to become 28 km long with a revised 6,710 ML entitlement servicing six farms (Figure 1). Specific components included:

- Installation of a new pump station on the Macquarie River below Warren.
- Construction of 7 km of new channel to link with the existing Tenandra Channel 64 km downstream of the existing Tenandra pump site.
- Lining 3.1 km of channel with compacted moisture-conditioned selected clay to minimise seepage.
- Decommissioning approximately 12 km of the main channel between the Top Scheme and Bottom Scheme, as well as 5.6 km of branch channels.

It was estimated this component would achieve 1,887 ML of water savings (assuming 100% allocation).

2.4.2.3 Scheme Rationalisation and creation of 'Loss Account'

Existing and rationalised members agreed to release a total of 13,894 ML of General Security water from the co-held Water Access Licence (WAL). Of this, 12,504 ML would be transferred to the Commonwealth and 1390 ML would be transferred to a separate WAL held by the Scheme. This so-called 'Loss Account' would ensure the long-term viability of the Scheme for its remaining members (refer to Section 6.11).

2.4.2.4 On-farm efficiency projects

The application included provision to upgrade the irrigation operations of three Scheme members to allow more efficient use of smaller allocations and reduced on-farm losses. These projects comprised:

- The construction of more efficient water storage facilities on 'Milawa', resulting in water savings of about 408 ML/year.
- The construction of a new clay-lined delivery channel and improvements to the existing drip irrigation system on 'Bellevue', resulting in water savings of about 311 ML/year.
- The conversion of 148 ha of bay irrigation to centre pivot irrigation on 'Old Bundemar', resulting in water savings about 140 ML/year.

It was estimated this component would achieve 859 ML of water savings (assuming 100% allocation).

2.4.3 Forecast program outcomes and benefits

The proposed Modernisation Project would enable the Scheme to become more efficient by reducing conveyance losses, regardless of water allocation. This would allow farmers to best match water supply to their demand patterns, as well as reducing the need for on-farm water storage and associated seepage and evaporation losses. In turn, this would make more water available for increased crop production and the potential gross revenue from irrigation.

Importantly, the modernised Scheme would suit current and future farm design and crop requirements by being able to efficiently deliver large volumes of water for high flow surface irrigation systems or lower flows at a constant rate for sprinkler or sub-surface irrigation systems. The modernised Scheme would also enable the temporary and permanent transfer of water entitlements from less efficient schemes or private irrigators pumping directly from the Macquarie River.

The PIIOP application estimated the Modernisation Project would directly contribute $22 million to the local regional economy via the supply of goods and services, as well as generating $20 million of agricultural crops and a further $50 million of flow-on benefits for the local economy in 100% allocation years.

2.4.3.1 Forecast water savings

The PIIOP application forecast total water savings of 13,894 ML (assuming 100% allocation). Savings included:

- 2,793 ML from improved water delivery efficiency via increased efficiency of the overall Scheme network.
- 859 ML from the increased on-farm efficiency of three individual members.
- 10242 ML made available from rationalisation of water entitlements on the Scheme.

Most of the forecast water savings stemmed from the rationalisation of the existing Tenandra Scheme and the decommissioning of a significant length of leaky channel. Additional savings would be achieved by clay-lining selected leaky sections of remaining channel.

Clay-lining was chosen to reduce seepage because of its proven record in achieving water savings, cost-effectiveness and life expectancy of at least 40 years. Trials conducted by Tenandra and other schemes operating in the Macquarie Valley and southern NSW had previously demonstrated the effectiveness of clay-lining in reducing seepage. Sections of the Tenandra Channel were clay-lined in the 1980s and 1990s.

2.4.3.2 Forecast costs

Nejuru Pty Ltd applied for $40,456,890 in funding from the Australian Government via the Private Irrigators Infrastructure Operators Program in New South Wales. This amount included $23,090,640 for the construction of earthworks and other infrastructure and $17,366,250 to acquire surplus water entitlements resulting from decommissioning the central part of the Scheme.

The Scheme offered to return 12,504 ML of General Security water entitlements to the Commonwealth in its bid to secure funding. The level of funding sought represented a total cost of $3,236/ML transferred to the Commonwealth.

In April 2010, the Australian Government approved funding of $37,975,140 for the described modernisation plan for the Tenandra Scheme.

3.0 Administration

3.1 Nejuru Pty Ltd

Prior to the Modernisation Project, the Tenandra Scheme was an Unincorporated Association governed by a Deed of Constitution (24 September, 1973). As an Unincorporated Association, the Scheme was not a legal entity and could not hold assets, except through its trustee, and its members were individually and personally liable for debts incurred by the Scheme.

Nejuru Pty Ltd is a registered company owned by the Scheme to hold property (e.g. the pump station at Gin Gin Weir and workshop in Warren) on behalf of the Scheme and to enter into contracts. Nejuru Pty Ltd has eight directors, all of whom are Scheme members. Six are also on the Scheme Management Committee.

Nejuru Pty Ltd, acting on behalf of the Tenandra Scheme, successfully applied for funding to the Australian Government funding under the Private Irrigators Infrastructure Operators Program in New South Wales and supervised all aspects of the Modernisation Project.

Table 1: Nejuru Pty Ltd executives

Position	Name
Chair	Angus O'Brien
Vice Chair	Anthony A. McAlary
Treasurer	Mark McKay

3.2 Scheme management and governance

Tenandra Scheme is managed by a Management Committee, which comprises 10 members elected by voting right holders at the annual general meeting. The Management Committee meets as necessary during the year. Sub-committees are appointed to research and implement specific tasks, reporting to the Management Committee as necessary. A part-time Channel Manager supervises the Scheme's operations. Administrative services are outsourced.

Table 2: Tenandra Scheme executives

Position	Name
Chair	Angus O'Brien
Vice Chair	Anthony A. McAlary
Secretary	Richard Wass
Treasurer	Ford Ruskin Rowe

3.3 Merged Tenandra and Greenhide Schemes

The modernisation planning process considered several options to reconfigure the Top Scheme, including merging it with the Greenhide Joint Water Supply Scheme, a small private irrigation system that supplied water to four farms via 12 km of channel. Its two members, who held General Security, Supplementary and Stock & Domestic water access licences totalling 8,433 ML, were initially opposed to merging the two schemes because the proposed reconfiguration offered insignificant benefits but could incur additional operational and management challenges.

The planning process continued to explore reconfiguration options for the Top Scheme using the existing Gin Gin pump station and channel. Examination of a digital elevation model in September 2009 revealed a new reconfiguration of a merged Tenandra/ Greenhide Scheme that would offer significant water savings, improved distribution efficiency (particularly in low allocation years) and reduced maintenance costs for Greenhide members.

Greenhide members were again consulted and a subsequent ground survey confirmed the feasibility of joining the two channels. Greenhide members voted unanimously to merge with the Tenandra Scheme. Under the agreement, Greenhide maintained its separate water entitlement, assumed 51% ownership of the 12 km of Greenhide section of the Top Scheme and agreed to fund 40% of the merged Scheme's maintenance costs and 50% of its water losses.

3.4 Land easements

Formal easements for land supporting existing channels and infrastructure owned by the Scheme were negotiated with landholders along the Top and Bottom Schemes to ensure the perpetuity of the Scheme. Previously, access was ensured via a Deed of Constitution with Scheme members and caveats with non-members. Nejuru Pty Ltd performed all negotiations. It was necessary to purchase a narrow strip of land and to provide compensation to three landholders to obtain these easements. Booth Brown Legal, Warren, NSW, prepared all contracts.

4.0 Planning

4.1 Refinement of preliminary design

The modernisation plan described in the PIIOP application was developed by Aquatech Consulting, Narrabri, using soil, electromagnetic induction (EM) and elevation surveys. The preliminary plan was then refined by a number of consultant engineers and surveyors, including:

- SMK Consultants, Moree
- Gleeson Surveying, Narrabri
- Tahlee Consulting Services, Gunnedah
- Aquatech Consulting, Narrabri

One of primary design considerations was how to achieve the desired total flow rate of 240 ML/day on both the Top and Bottom channels and ensure delivery to existing outlets at the same height as the existing channel. SMK Consultants, Moree, was commissioned to conduct additional elevation surveys. Sustainable Soils Management, Warren, and Barnson Pty Ltd, Dubbo, were commissioned to conduct additional geotechnical assessments to ensure the channel construction material was suitable for a compacted clay liner.

4.2 Approvals process

The existing and proposed new linkage channels of the Top and Bottom Schemes cross several public roads, private land owned by more than 20 landholders, a travelling stock reserve, the Ewenmar Creek, the Five Mile Cowal and the wider floodplain of the Macquarie River.

The revised plan was submitted to various NSW Government departments to obtain necessary approvals (Table 3). The application for Works Approval included three revisions to address various concerns raised during the approval process, which took more than 12 months to complete (Table 4). Agreements with private landholders had previously been negotiated and were included in the PIIOP application.

Table 3: Approvals process

Approval required	Authority	Summary of criteria
Construction of channel across floodplain	NSW Office of Water & NSW Department of Climate Change and Water	Compliance with Macquarie Valley Floodplain Management Plan. Above Warren: Allow passage of a 1990 flood (179,500 ML/day at Narromine) without causing significant increase in floodwater levels or change in flood flow. Below Warren: Allow passage of a 1955 flood (501,000 ML/day at Narromine) without causing significant increase in floodwater levels or change in flood flow.
Vegetation	Central West Catchment Authority	Remnant native vegetation can be cleared to allow construction of irrigation channels as a Routine Agricultural Maintenance Action.
Fish	NSW Department of Primary Industries	Minimise disturbance to fish habitat and not kill fish.
Construction of channel across Travelling Stock Reserve	Land and Property Management Authority	Minimise impact of channel on other users of the Travelling Stock Reserve. Protect Native Title Rights.
Construction of four road crossings	Narromine Shire Council & Warren Shire Council	Ensure that road crossing does not degrade road. Avoid interference with traffic flow during construction.

Table 4: Milestones in approval process for the Works Approval.

Date	Milestone description
06/09/10	Initial contact between project managers and Office of Water (OoW). Project Managers had impression that OoW were keen to wrap up approval by end of month.
15/09/10	Field visit by OoW at which request was made for detailed modelling of the impact of the Greenhide Channel on flood flows and a Review of Environmental Factors.
Nov 2010	Channel redesigned to account for issues raised during initial visit. Negotiations to gain access to model used in development of floodplain management plan. Surveying to get data to input to model.
22/11/10	Flooding throughout eastern NSW, including a peak flow of 186,000 ML at Narromine, demonstrated current works had minimal impact on flood flows in the Macquarie Floodplain.
08/12/10	Draft application submitted as a scoping report.
18/01/11	Review of environmental factors submitted.
Feb – April 2011	Discussions between government agencies and designers lead to modifications of proposed channel to account for concerns.
28/05/11	Application for works approval submitted.
21/10/11	Second field visit. Decision that application is to be assessed under Section 92 is conveyed to proponent.
Jul – Aug 2011	Minor modifications to application to account for issues raised during visits and discussions.
23/09/11	Works Approval 80WA704499 issued.

4.2.1 NSW Office of Water

Approval was required from the NSW Office of Water to ensure the proposed works would not impede the flow of water across the Macquarie Floodplain. This process took considerably longer than expected, with more than 12 months elapsing between initial discussions and the necessary Works Approval being issued (Table 4). One of the key decisions required was whether the application be assessed as flood control works under Part 8 of the Water Act (1912) or as water supply works under Section 92 of the Water Management Act (2000). Unfortunately, the decision that the application was to be assessed under Section 92 (a process which required significantly less detail) was only conveyed to the applicant nine months after initial consultation.

4.2.2 NSW Department of Primary Industries

Approval was required from the fisheries branch of NSW Department of Primary Industries to demonstrate the proposed construction works would not endanger aquatic organisms or habitat. A Work Method Statement was prepared in April 2011 but could not be submitted until November 2011, as several sections were contingent upon conditions stipulated in the Works Approval granted by NSW Office of Water. In turn, tenders for the construction of siphons could not be issued until the requirements of the Fisheries Permit were known. A permit was issued on 17 January 2012.

4.2.3 Property vegetation plan

Approval was required for the removal of some remnant native vegetation to allow construction of the proposed works. After discussion with various government agencies, it was determined that approval to construct the new channel under the Water Management Act extinguished the criteria of the Native Vegetation Act. Nevertheless, the Central West Catchment Authority assessed the likely effects of channel construction using tools and methodology of the Native Vegetation Act. This process took eight months.

4.2.4 Travelling Stock Reserve

Approval was required to ensure the proposed works did not impact on other users of NSW Government Crown Lands or impact on indigenous artefacts. NSW Government Crown Lands Division was concerned about the impact of Siphons 1 and 2 upon access to the Travelling Stock Reserve. The Nejuru Board agreed to change the design of both siphons and the matter was resolved in May 2011. A site survey conducted in February 2011 indicated no presence of indigenous artefacts or carved/scarred trees along the channel alignment.

4.2.5 Local Government

Approval was required for the construction of two crossings under Bundemar Road associated with the installation of Siphons 1 and 2. Warren and Narromine Shire Councils have clear requirements for the construction of road crossings. Approvals for both crossings were obtained quickly and did not interfere with the project timeline.

4.3 Preparation and approval of revised plan

The revised plan, also prepared by SMK Consultants, incorporated the requested changes from NSW Office of Water and NSW Government Crown Lands Division:

- *Siphon 1 (which carries water from the 'Old Bundemar' Offtake on the Top Scheme channel beneath the Bundemar Road, the Travelling Stock Reserve, the Ewenmar Creek and adjoining floodplain to 'Old Bundemar'):* The preliminary plan proposed construction of a new offtake culvert feeding 580 m of below-ground channel, including a culvert under Bundemar Road and 100 m of 750 mm diameter steel pipe over the Ewenmar Creek weir pool. NSW Government Crown Lands Division was concerned about the impact upon access to the Travelling Stock Reserve. The revised plan consisted of 755 m of buried 800 mm diameter High Density Polyethylene (HDPE) pipe, part of which was sunk across the bed of Ewenmar Creek, to prevent interference with the riparian system.

- *Siphon 2 (which carries water from the Top Scheme main channel beneath the Bundemar Road, the Travelling Stock Reserve, Ewenmar Creek and the adjoining flood plain into 'Methalibah'):* The original design comprised approximately 600 m of 2100 mm diameter reinforced concrete pipe. NSW Office of Water was concerned about potential impact on floodwaters. The revised plan comprised 392 m of buried 1600 mm diameter HDPE pipe. In turn, this required upgrading the Greenhide channel to 2 m deep x 6 m wide ensure sufficient head to deliver the desired capacity of 240 ML/day.

NSW Office of Water requested a number of other changes to the design, including clay-lining the new linkage channel of the Top Scheme channel; installing a wider floodway opening and lowering the height of the channel bank on 'Macquarie View'; and lowering the height of the channel bank at 'The Cedars'. These changes were incorporated into the revised plan and resubmitted for approval by NSW Office of Water and NSW Government Crown Land Division. These approvals were obtained by late 2011.

4.4 Certification of final plan

The revised plan was reviewed by the Project Manager, RPMS Pty Ltd, and certified by TEG Consulting Engineers, Innisfail, Qld, with consideration to design and materials, physical limitations and statutory regulations.

4.5 Tendering process

The Tenandra Scheme Modernisation Project was divided into a number of sub-projects, with detailed tenders prepared for each sub-project in accordance with the final approved plan, specifications and timelines (Table 5).

Tenders were invited from suitable organisations for all projects with estimated value of more than $30,000 (i.e. channels and structures, siphons, pumps and power, controls and meters). For smaller projects with an estimated value of less than $30,000, a minimum of three quotes were requested from local suppliers that met the board's criteria for their ability to complete the project to specification, budget, timelines and the ability to comply with workplace health and safety policies.

All tenders were managed in accordance with Commonwealth Procurement Rules (July 2012), which seek to deliver maximum value via the efficient, effective, competitive, ethical and accountable procurement of goods and services.

Table 5: Procurement method

Sub-project	Method of procurement	Refer to
Channels and structures	Lump sum contract	Section 6.1
Channel reconstruction	Managed directed by the Project Manager	Section 6.2
Siphons	Design and construct	Section 6.3
Controls and meters	Design and construct	Section 6.4
Pumps and power	Design and construct	Section 6.5
Fencing	Managed directed by the Project Manager using contractors and procured materials	Section 6.6
On-farm efficiency projects	Managed directed by applicants with assistance from Project Manager and Superintendent's Representative	Sections 6.7, 6.8 & 6.9
Decommissioning	Managed directly by the Project Manager and Superintendent's Representative	Chapter 6.10
Establishment of Loss WAL and rationalisation	Managed directly by the Board and Project Manager	Section 6.11

4.6 Awarding of contracts

A tender assessment was undertaken by the project management team, who provided their tender evaluation report to the Board, who assessed these recommendations based on available information in consultation with members. Contracts were awarded to those applicants that met the Board's criteria for their ability to complete the project to specification, on time and on budget and ability to comply with workplace health and safety policies. Insurances, work schedules, health safety and environment plans, and quality assurance plans were established for each sub-project. In most cases, Nejuru Pty Ltd assigned a sub-committee to act as the board's representative for each sub-project.

5.0 Management of tenders

5.1 Project governance

Tenandra Scheme and Nejuru Pty Ltd are distinct organisations. Throughout the Modernisation Project, the Scheme maintained responsibility for operation of the existing irrigation system, while Nejuru Pty Ltd had responsibility for management of the Modernisation Project.

The Nejuru Board met on a fortnightly or monthly basis throughout the duration of the project to review progress reports supplied by the Project Manager and to approve plans, tenders, contracts and claims. Board members participated in site inspections as required throughout the construction phase.

The Board constantly reviewed planned expenditure as tenders were received and claims made. By necessity, this led to a reduction in the scope and expenditure of planned works in some sub-projects. The construction of the new link channels and pump stations were deemed to be high priority sub-projects. Likewise, certain sub-projects were quarantined (e.g. on-farm works and member rationalisation) from budget changes.

5.2 Project management

On 13 August 2010 Nejuru Pty Ltd appointed RPMS Pty Ltd, a Goondiwindi-based project management and civil construction consultancy as Project Manager. Dick Sudholz, a retired earthmoving contractor from Goondiwindi, was appointed overall Project Manager/Site Supervisor, supported by RPMS CEO, Sean Rice (Table 6). RPMS engaged McCullough Robertson, Brisbane, to prepare contracts.

In November 2012, Nejuru Pty Ltd terminated its project management contracts with RPMS Pty Ltd and Sudholz Pty Ltd due to ongoing concerns about operational procedures, quality assurance, workplace health and safety and administration.

On 1 January 2013, Nejuru Pty Ltd appointed Warren-based soil consultancy, Sustainable Soils Management Pty Ltd, as Project Manager for the remainder of the modernisation project (Table 7). Sustainable Soils Management was intimately familiar with the project, having conducted the initial planning process in 2008/9, as well as providing ongoing soil survey and quality assurance services during the project.

In turn, Sustainable Soils Management engaged a large Dubbo-based construction company, David Payne Constructions, a company accredited with the Office of the Federal Safety Commissioner (FSC) to supervise the implementation of contracts, provide on-site supervision of sub-contractors and the implementation of on-site health and safety and environmental regulations.

Working in close partnership with Nejuru Pty Ltd, the new project management team proactively addressed and resolved identified quality assurance and workplace health and safety issues. All parties worked closely to supervise the completion of the project in accordance with the agreed specifications in time for the 2013/14 irrigation season. The Bottom Scheme began operations in September 2013 while the Top Scheme began operations in December 2013.

Table 6: Tenandra Project Management (2010–12)

Company	Role	Nominated representatives
RPMS Pty Ltd, Goondiwindi, Qld	Project Manager (including site supervision)	Dick Sudholz
	Administration	Sean Rice

Table 7: Tenandra Project Management (2013–15)

Company	Role	Nominated representative
Sustainable Soils Management Pty Ltd, Warren, NSW	Project Manager	David Duncan
David Payne Constructions Pty Ltd, Dubbo, NSW	Superintendent's Representative	Stephen Wonderley
	Site Supervisor	Aaron Payne

5.3 Quality assurance

All contracts were required to be managed in accordance with best management practices for the construction of earthen channels, as defined by the relevant Australian Standards listed in each tender. All contractors submitted detailed work schedules (including hold points), inspection and testing plans before completion of each contract.

5.4 Health, safety and environment

RPMS had prepared and implemented a HSE plan to ensure that all staff, contractors and sub-contractors understood and complied with relevant legislation and codes of practice. However, during the construction phase of the project, a Workplace Health and Safety Review undertaken by GHD and Departmental staff in early November 2012 found

> *"as a result of minimal records being available during the site inspection it is not possible to determine if Rice Project Management Services, Irribiz or Hawkins Civil have the appropriate Health and Safety management systems in place for this project. Some records were provided following the inspection however some of these were incomplete and did not form part of their team plan. Rice Project Management Services and Irribiz were unable to demonstrate that site and task specific risks have been identified for all aspects of the project, and risks are being controlled."*

Following the termination of the project management contract with RPMS, the Board engaged Sustainable Soils Management and ESQ Solutions, Brisbane, to prepare a Health, Safety and Environment Management Plan (November 2012) for the remainder of the project. This plan included policies for occupational health and safety, fatigue management, drugs and alcohol, environment and rehabilitation. This plan was approved by the Board and its implementation managed by ESQ Solutions, the Project Manager and Superintendent's Representative including the DPC team.

5.5 Communication with stakeholders

Sustainable Soils Management maintained communications between all stakeholders throughout the remainder of the project and provided detailed descriptions of workflow, progress and outcomes. Project manager, David Duncan, was in daily communication with Nejuru Pty Ltd Chairman, Angus O'Brien, and the Superintendent's Representative, Steve Wonderley.

In turn, the Superintendent's Representative, Stephen Wonderley, supervised all construction sites and management of contractors. Nejuru Pty Ltd Board maintained regular contact with the Commonwealth, Scheme Members and landholders. All stakeholders attended board meetings held fortnightly, monthly or bimonthly, as required.

6.0 Construction

6.1 Channels and structures

6.1.1 Description

The Tenandra Scheme main channel was split into two shorter and more efficient channels (i.e. the 'Top Scheme' and the 'Bottom Scheme'). The infrastructure of both channels was extensively reconfigured and/or upgraded to improve distribution efficiency.

Construction works undertaken on the new Top Channel (Figure 1) included:

- Upgrading the existing 12 km Greenhide channel. These works enlarged the channel to 2 m deep x 6 m wide, increasing its capacity from 140 to 400 ML/day.

- Construction of 9 km of new link channel from the end of the existing Greenhide channel at 'Fernehurst' to the existing Tenandra channel at 'Methalibah'. This 2 m deep x 4.5 m wide above-ground channel has a capacity of 240 ML/day.

- Construction of a 5 km new branch channel from the existing Tenandra channel to the 'Milawa' offtake. This 1.5 m deep x 4 m wide above-ground channel has a capacity of 100 ML/day.

- Clay-lining the entire length of the existing Greenhide channel, new link channel and 2 km of the new 'Milawa' branch channel. The clay liner was created by removing a horizontal section across the channel bed to a depth of 0.75 metres and to a width of four metres from each embankment (Figure 2). This material was replaced with compacted, moisture-conditioned clay material sourced from the channel overcut or local borrow pits.

- Construction of a 20 m and a 50 m piped floodway in the existing Greenhide channel to allow floodwater to cross the channel.

- Construction of two cross drainage culverts in the new link channel to allow local run-off water to flow under the channel through 'Methalibah'. The culverts were reinforced concrete pipes with pre-cast concrete headwalls at each end.

- Construction of four cross-channel culverts on the 'Milawa' supply channel to manage local run-off.

Construction works undertaken on the new Bottom Channel (Figure 1) included:

- Construction of 7 km of new link channel from the new pump station on 'Gillendoon' to the existing Tenandra channel on 'The Cedars'. This 2 m deep x 4 m wide below-ground channel has a capacity of 240 ML/day.
- Construction of a new 40 ML/day pump station on 'The Cedars' that discharges into an on-farm channel to replace a gravity-fed outlet.
- Construction of two cross-channel drains on 'Gillendoon' to manage local run-off.
- Construction of two cross-channel culverts to maintain irrigation supply and drainage on 'The Cedars'.
- Earthworks and culverts on certain sections of the existing Tenandra channel to reduce erosion and to eliminate 'dead water'.

The construction was split into six contracts covering three sections on the Top Scheme and three sections on the Bottom Scheme. Each contract included the installation of associated structures (Table 8).

Figure 2: Cross-section of the design for the compacted clay liner used to reduce seepage in the new Tenandra Scheme channels.

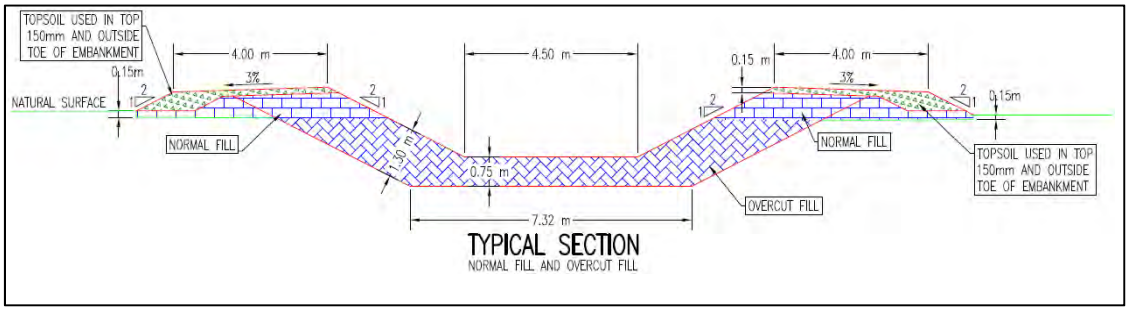


Table 8: Summary of contracts for channel construction

Contract	Description
Contract 10-130	Rebuilding and realigning the Greenhide Scheme and lining leaky sections with compacted moisture-conditioned clay.
Contract 10-131	Construction of link channel from Gibson's Lane to the No. 2 Siphon and lining with compacted, moisture-conditioned clay.
Contract 10-132	Construction of link channel from No. 2 Siphon to join to the existing Tenandra channel at 'Milawa' and lining the entire length with compacted, moisture-conditioned clay.
Contract 10-133	Construction of an unlined link channel from the Gillendoon pump station to the Umangla Cowal.
Contract 10-134	Construction of an unlined link channel from the Umangla Cowal to the Five Mile Cowal.
Contract 10-135	Construction of a lined and unlined channel from the Five Mile Cowal to the Tenandra channel in 'The Cedars'.

Figure 3: Construction of the new channel linking the Greenhide and Tenandra Scheme. The design included a 0.75 m moisture-conditioned compacted clay lining across the bed of the channel and to a width of four metres under each bank.

Figure 4: A channel crossing installed on 'Macquarie View' to allow vehicle access and floodwater drainage to pass over the channel.

6.1.2 Key contractors

The primary contractor for the construction of channels and associated structures was Hawkins Civil Construction, Loganholme, Qld, who sub-contracted about half of the Top Scheme and about 20% of the Bottom Scheme to a range of local, regional and metropolitan suppliers (Table 9).

Table 9: Summary of contractors and approximate contract value for channel construction and installation of structures.

Contractor	Location	Service provided	Approx contract value (%)
Hawkins Civil Construction	Loganholme, Qld	Earthworks and civil construction, machinery, operators and supervisors	53%
Gemhawk	Londonderry, NSW	Machinery hire	15%
Bunyan	Dubbo, NSW	Machinery and operators	5%
B & D Brouff Earthmoving	Warren, NSW	Machinery and operators	2%
Humes Limited	Tamworth NSW	Pipes and structures	16%
Landpac	Seven Hills, NSW	Machinery and operator	1%
RBK	Warren, NSW	Rectification of Section 7	2%
Bruno Altin	Griffith, NSW	Pipes and structures	6%

6.1.3 Budget

The funding agreement allocated a budget of $6,060,334 for earthworks and $1,566,823 for structures. The funded amount was almost double the estimate contained in the 2009 plan owing to major changes to the design, particularly to the Top Scheme.

Final construction costs were just under $7.8 million and $285,654.33 (3.7%) over budget due to quality assurance issues (refer to Section 6.1.4). As this sub-project was the primary source of forecast water savings, funds were diverted from lower priority projects to make up this shortfall.

Table 10: Summary of budget and final costs for channel construction and installation of structures.

Contract	Budget (ex GST)	Final cost (ex GST)
Channel earthworks	$6,060,334.00	$6,127,311.40
Channel structures	$1,566,823.00	$1,654,150.76
Total	**$7,627,157.00**	**$7,781,462.16**

6.1.4 Managing claims

Construction costs associated with upgrading the Top Scheme channel were significantly more expensive than the 2009 budget and the tendered estimates due to:

- *Revisions to the Greenhide channel:* The final plan had to be revised to include the installation a 50-metre floodway using twin 1500 mm concrete pipes to satisfy NSW Office of Water requirements. In addition, a 700 metre section of channel was straightened to allow easier land management and channel maintenance.

- *Revisions to clay-lining:* The Board elected to clay-line the entire length (21 km) of the existing Greenhide channel, the new link channel on the Top Scheme to the junction of the existing channel 1.5 km of the new 'Milawa' supply channel for ease of construction, rather than the 13.1 km of leaky channel identified by geotechnical surveys. This increased cost was offset by the decision not to clay-line 6 km of leaky sections on the Bottom Channel and to reduce the scope of works in the channel reconstruction project.

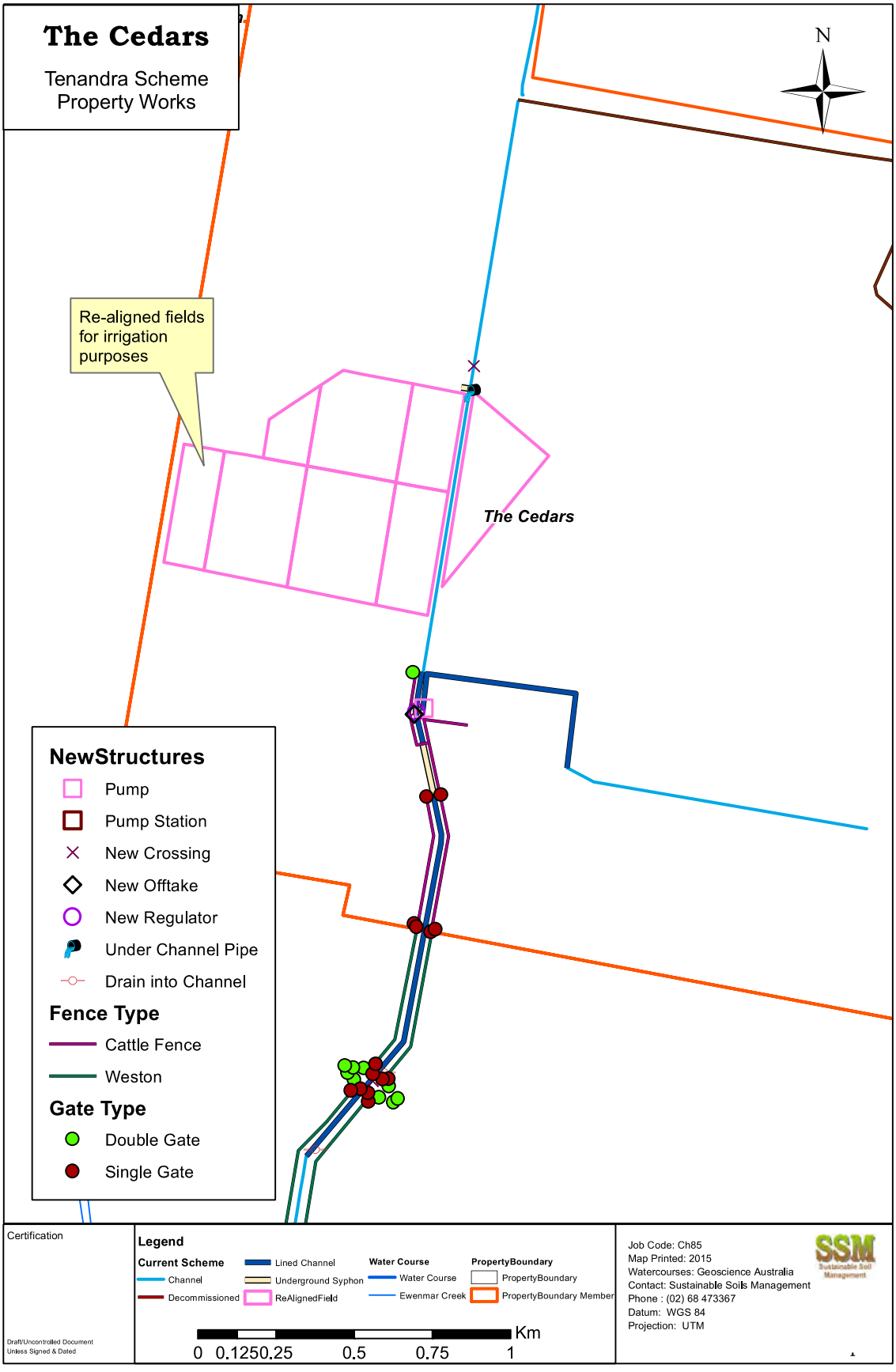
- *Quality assurance issues:* About 3 km of the upgraded Greenhide Channel had to be reconstructed after quality assurance testing indicated the depth of the clay lining was insufficient. Another 6 km of link channel had to be reconstructed after soil surveys indicated the depth of clay-lining, moisture-conditioning and/or compaction were non-compliant with the tender specifications. A further 3 km of embankment of the link channel had to be recompacted using an impact roller.

Construction costs associated with upgrading the Bottom Scheme channel were more expensive than both the 2009 Budget and the tender estimates due to:

- *Clay-lining approximately 2 km of the main channel.*

- *Revisions to the design of the new supply channel on 'The Cedars':* Detailed soil surveys indicated that the proposed below-ground channel was not feasible, necessitating the construction of a clay-lined above-ground channel, which in turn, required the construction of a new pump station on the property as the channel offtake (Figure 5).

Figure 5: Works undertaken on 'The Cedars'



6.1.5 Time

The period taken to complete each contract was five to seven times longer than planned (Table 11), delaying completion of the project by more than a year. Two sections of the Top Scheme took more than 12 months to complete due to quality assurance issues (refer to 6.1.4). Short extensions of time (approximately three weeks) were requested and granted on the Top Scheme contracts.

Likewise, the Bottom Scheme contracts took five to seven times longer to complete than initially planned. Extensions of time, including wet weather, added three weeks to the construction schedule but had little impact on overall time taken to complete the works.

The productivity of this work could have been improved by better quantity and reliability of plant, equipment and staff; cash flow; access to sub-contractors; fuel supply; and supply of concrete and concrete structures (Aaron Clifford, *pers comm*.). Additionally, the programming of works meant that each section was not completely finished and approved before commencing the next section, which meant that the worksite was stretched over 20 km, making management and supervision difficult and inefficient.

Table 11: Time taken to complete channel construction and structures (Contracts 10-130 to 10-135)

Contract	Tender estimate (weeks)	Extension of time required (weeks)	Time taken (weeks)	Variation (weeks)
10-130	9	3	44	+33
10-131	8	3	54	+46
10-132	8	3	54	+46
10-133	4	3	30	+26
10-134	5	3	25	+20
10-135	6	3	30	+24

6.1.6 Quality assurance

RPMS Pty Ltd, the initial project manager, developed and implemented a Quality Management System to meet the requirements of international standard ISO 90001 (2000) for design, development and construction. The contractor was responsible for providing bulk density and compaction tests as specified in the contract.

Barnsons Pty Ltd, Dubbo, provided bulk density, compaction and moisture tests to Hawkins Civil Construction. Sustainable Soils Management Pty Ltd was contracted directly by Nejuru Pty Ltd to conduct infiltration tests in the new channels.

These tests indicated that significant sections of new or upgraded channels on the Top Scheme were non-compliant with the tender specifications. About 4.5 km or half of the first 9 km of the upgraded Greenhide channel had to be reconstructed after quality assurance testing indicated the depth of the clay lining was insufficient. Another 6 km or two-thirds of the 9 km of link channel had to be reconstructed after soil surveys indicated the depth of clay-lining, moisture-conditioning and/or compaction were non-compliant with the tender specifications. The remaining third was impact rolled to improve compaction.

Figure 6: Infiltration tests were conducted as part of the quality assurance program to test the permeability of the compacted clay liner.

6.1.7 Work health and safety

Hawkins Civil Construction developed and implemented an Integrated Management System incorporating an OHSE Management Plan to ensure the construction process was controlled and met delivery expectations. The OHSE Management Plan focussed on quality, environment, health and safety for Nejuru, staff, sub-contractors and the public with the aim of achieving an accident and issue free workplace.

The plan included identification of hazards and risk analysis to prevent incidents and minimise risks. Understanding of roles and responsibilities of all employees was achieved through regular and ongoing communication and training. Regular pre-start meetings and toolbox meetings were held to ensure staff were briefed and debriefed as necessary.

The lack of injury, damage and lost time from three serious incidents (a scraper contacting a powerline, a scraper roll-over and a water truck roll-over) indicated that the OHSE Plan had been effective.

The Department conducted a follow up Workplace Health and Safety Review using URS as a consultant in February 2013. The review found a significant improvement in the application of workplace health and safety requirements compared to the first review. A number of minor recommendations were made to the Tenandra Board to improve the Board's compliance with its obligations under WHS legislation. These recommendations were accepted by the Board.

6.1.8 Environment

All earthworks, siphons and structures were constructed in compliance with the Macquarie River (Narromine to Oxley Station) Floodplain Management Plan (2008) and approvals outlined in 4.2 and 4.3. Fuel, oil and rubbish were removed from the site.

6.2 Channel reconstruction

6.2.1 Description

The scope of intended works for upgrading various sections of the existing channels was significantly reduced from the original proposal due to budget constraints. Priority was given to the Top Scheme, with specific focus on reshaping the existing channel downstream of the Junction Regulator to improve delivery efficiency to the three remaining members on the bottom section of the Top Scheme. Whereas the existing channel had a capacity of about 400 ML/day, only 50 ML/day would now be required.

Other works targeted specific sections of the Top Scheme channel that had deteriorated, resulting in leakage and 'dead water'. The existing bed of the channel varied in width from 3.5 to 5 metres and varied in depth from 1 to 1.5 metres, resulting in drainage problems. The existing channel had a gentle batter of approximately 4:1 on its northern side and 1.5–2:1 on its southern side. Furthermore, the bed was covered with up to 300 mm of silt.

Approximately 20 km of existing channel was reshaped to form a smaller and more efficient channel within the current structure. The existing bed was de-silted, dried, graded and levelled to achieve a 2.4 m width and a uniform 1:5000 grade. The northern batter was cut to achieve a profile of 2.5:1, while the southern batter was reshaped to form a new bank within the existing channel. The bed and both batters were then lined with compacted, moisture-conditioned clay material. The crest of both banks was graded to drain away from the channel, preventing rainfall run-off from entering the channel.

6.2.2 Key contractors

Six local earthmoving contractors were invited to attend a site inspection, along with Board members and project managers, in August 2013. Four attended the site inspection on 14/08/13. Survey and design information was provided to the contractors, along with ideas to rebuild and reshape the channel. Contractors were invited to respond with a rebuilding methodology, a quote for works and schedule of rates, with Section 12 as the first priority.

Following review of all responses, the Board awarded the contract for the channel upgrading sub-project to G. & L. Barnett Earthmoving, Warren. Following the successful completion of Section 12, the Board engaged G. & L. Barnett Earthmoving to continue channel rebuilding on a section-by-section basis.

6.2.3 Budget

The funding agreement allocated a budget of $498,725 for channel reconstruction and realignment. This budget was significantly reduced to $213,070 in order to fund the increased expenditure on channels and structures (Table 12).

Table 12: Summary of budget and final costs for channel reconstruction and alignment.

Contract	Budget (ex GST)	Amount paid (ex GST)
Channel reconstruction	$359,488.00	$169,915.13
Channel realignment	$139,237.00	$ 43,155.54
Total	**$498,725.00**	**$213,070.67**

6.2.4 Managing claims

Plant, including two excavators, a grader and a vibrating roller, was hired on an hourly basis (including fuel and operators). All claims from the contractor were processed and paid in full during construction.

6.2.5 Time

Channel reconstruction works were undertaken in a sequential (section-by-section) process between August and December 2013.

6.2.6 Quality assurance

This project was managed by Sustainable Soil Management on behalf of the Nejuru Pty Ltd. Project Manager, David Duncan, and Sustainable Soil Management Project Supervisor, Steve Howlett, and Nejuru Pty Ltd Director, Mark McKay, inspected each section upon completion.

6.2.7 Work health and safety

Nejuru Pty Ltd. Project Manager, David Duncan, and Project Supervisor, Steve Howlett, conducted start-up and regular ‘tool box’ meetings with the contractor. No Incident/Accident Reports were reported.

6.2.8 Environment

The channel reconstruction project posed no threats to the environment, as all works occurred within the existing channel structure. Site inspections were conducted during the course of the project and no environmental issues were identified. All fuel, oil and rubbish were removed at the completion of the project.

6.3 Siphons

6.3.1 Description

Four siphons were constructed to convey water beneath roads, waterways and floodplains (Figure 1):

- Siphon 1 is a 765 m long, 800 mm diameter High Density Polyethylene (HDPE) pipe that carries water from the 'Old Bundemar' offtake on the Top Scheme channel beneath the Bundemar Road, the Travelling Stock Reserve, the Ewenmar Creek and adjoining floodplain to 'Old Bundemar'. It is designed to convey a maximum capacity of 41 ML/day.

- Siphon 2 is a 390 m long, 1600 mm diameter HDPE pipe that carries water from the Top Scheme main channel beneath the Bundemar Road, the Travelling Stock Reserve, Ewenmar Creek and the adjoining flood plain into 'Methalibah'. It is designed to convey a maximum capacity of 240 ML/day.

- Siphon 3 is an 80 m long, 1600 mm diameter HDPE pipe that carries water from the Bottom Scheme channel beneath the Ewenmar Creek on 'Gillendoon'. It is designed to convey a maximum capacity of 240 ML/day.

- Siphon 4 is a 140 m long, 1600 mm diameter HDPE pipe that carries water from the Bottom Scheme channel beneath the Five Mile Cowal and adjoining floodplain on 'The Cedars'. It is designed to convey 240 ML/day.

Figure 7: The inlet of Siphon 4, which transfers water beneath the Five Mile Cowal and adjoining floodplain on 'The Cedars'.

Figure 8: Bobby Sal from Irribiz Griffith, standing alongside Siphon 2 prior to installation. Constructed of 1600 mm diameter HDPE pipe, Siphon 2 traverses 392 m over the Travelling Stock Reserve, Ewenmar Creek and adjoining flood plain into 'Methalibah'.

Figure 9: Siphon 3 transfers water from the Bottom Scheme channel beneath Ewenmar Creek, which was enclosed in a cofferdam (left) during construction, on 'Gillendoon'.

6.3.2 Key contractors

Five companies were invited to submit tenders for the design and construction of the four siphons. Submissions were received from three of these companies. Griffith-based business, ICI Industries Pty Ltd (trading as Irribiz), was awarded the contract for the design and construction of the four siphons. The supply of materials accounted for more half of the tender value, while installation, which was sub-contracted to a local company, accounted for about one third of the tender value (Table 13).

Table 13: Summary of contractors and approximate contract value for siphon construction (Contract 10-129)

Contractor	Location	Service provided	Contract value (%)
ICI Industries Pty Ltd (Irribiz)	Griffith, NSW	Head contractor	3%
W3 Plus	Melbourne, Vic	Detailed design	1%
M & PM Oriel Pty Ltd	Warren, NSW	Installation of poly pipework and associated fittings across creeks to each channel connection	35%
Iplex Pipelines	Sydney, NSW	Supply of poly pipe and design works	54%
Holcim (Humes)	Tamworth, NSW	Supply of concrete headwalls	2%
Phoenix Plastics	Brisbane, Qld	Supply of poly welding services	5%

6.3.3 Budget

The funding agreement allocated a budget of $1,826,038 for the construction of four siphons. This was significantly less than initial planning estimates owing to the decision to use High Density Polyethylene (HDPE) pipe in preference to reinforced concrete pipe.

Final construction costs were $1,930,840.96, which is $104,802.96 (5.7%) over budget due to significant modification to the design of the siphons during the approvals process (Table 14). As this sub-project formed a pivotal part of the primary source of forecast water savings, funds were diverted from lower priority projects to make up this shortfall.

Table 14: Summary of budget and final costs (Contract 10-129)

Contract	Budget (ex GST)	Amount paid (ex GST)
Siphon 1	$459,816	$463,826.76
Siphon 2	$606,434	$757,539.70
Siphon 3	$520,900	$445,201.86
Siphon 4	$238,888	$264,272.64
Total	**$1,826,038**	**$1,930,840.96**

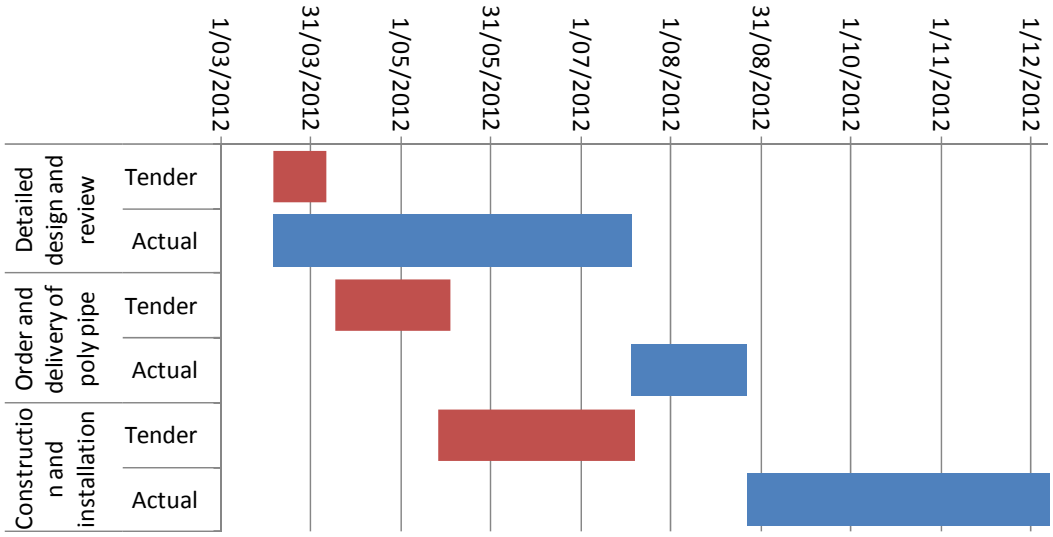
6.3.4 Managing claims

Progressive payments were paid on claims at regular intervals during the construction phase.

6.3.5 Time

The time taken to design and review this project was 107 days longer than estimated, primarily due to changes in the design and the time taken to obtain approvals from NSW government authorities (Figure 10). An outlet pipe on Siphon 3 also contributed to these delays. The time taken to construct the four siphons was 61 days longer than the estimated time in tender. This was due to the increased length of Siphons 1, 2 and 3, alterations to the headwalls and a delay due to a review of pipe laying procedures.

Figure 10: Time taken to complete siphon construction (Contract 10-129)



6.3.6 Quality assurance

Quality assurance by SSM and DPC found the shape of Siphon 1 to be non-compliant with the flow meter manufacturer's specifications but within tolerance of the pipe manufacturer's specifications. It appears the pipe may have become deformed (i.e. oval shaped) as a result of heavy traffic during channel construction. This ovality may affect metering accuracy of the Old Bundemar outlet. This will be monitored and if necessary, the pipe will be steel-banded and the flow meter recalibrated to ensure the accuracy of flow meter readings.

Figure 11: Quality assurance procedures on Siphon 1, including checking depth of pipe to ensure a minimum cover of 600 mm over the 800 mm HDPE pipe.

6.3.7 Work health and safety issues

Irribiz developed and implemented a Work Health Safety and Environmental Management Plan (WHSEMP) to ensure compliance with relevant legislation and permit conditions. This WHSEMP required employees and contractors to complete Occupational Health Safety and Environment (OHS&E) Site Hazard Inspection Reports and to report lost time injuries, near miss incidents and dangerous occurrences and hazards. One OHS&E Site Hazard Inspection Report was completed across all work sites (Table 15).

Table 15: Summary of OHS&E Site hazard inspection report

Location	Date	Issues raised	Controls required	Responsible
Whole site	23/8/12	Workcover not informed of 1.5 m trench	Contact Workcover	M & PM Oriel Pty Ltd
		Rubbish on site, including cigarette butts	Pick up litter	All employees and contractors

Two Incident/Accident Report Forms were completed (Table 16). RPMS Pty Ltd, the initial project manager, conducted two Safety Site Inspections (Table 17). David Payne Constructions, the second project manager, conducted a Non-Conformance/Corrective Actions Report to address shortcomings with Safe Work Method Statement (SWMS) and Hazardous Chemical documentation. Irribiz implemented corrective/preventative actions to address these concerns (Table 18).

Table 16: Summary of safety incidents/accidents

Location	Date	Incident details	Injuries	Work days lost	Preventative action
Siphon 2	2/8/12	Chain used for lifting pipe broke whilst under load	0	0	Chains were replaced by slings for lifting pipe. Exclusion zones were introduced around excavators
Siphon 2	31/1/13	Chain dog flung open when unloading headwall	Cut thumb on left hand. First aid was given on site	0	Workers to take greater care when unloading in future

Table 17: Summary of safety site inspections

Location	Date	Issues raised	Controls required	Responsible
Siphon 2	21/9/12	M & PM Oriel Safe Work Method Statements (SWMS) were signed by staff but not by an authorised person	Staff member to authorise the SWMS	Managing Director, M & PM Oriel Pty Ltd
		The Safety Manual was not signed	Staff member to authorise the Safety Manual	Managing Director, M & PM Oriel Pty Ltd
Siphons 1, 2 & 3	26/10/12	None	N/A	N/A

Table 18: Results of non-conformance/corrective actions report

Issue	Corrective/Preventative action
A number of SWMSs were generic and had not been reviewed/updated to reflect the current work environment	All SWMS were being reviewed at the time
Limited evidence was sighted of the SWMS being signed off in all areas by the nominated employees	All new ones
A number of the SWMS had surpassed their review date.	All SWMSs were being reviewed at the time
No Hazardous Chemical Register has been developed and implemented.	ICI Industries to update list and inform project staff.
A number of the Safety Data Sheets had exceeded the five-year expiry date.	ICI Industries to update list and inform project staff.

6.3.8 Environment

Irribiz developed and implemented a Work Health Safety and Environmental Management Plan (WHSEMP) to ensure compliance with relevant legislation and permit conditions. Site inspections were conducted during the course of the project and no environmental issues were identified.

6.4 Channel controls (regulators, offtake gates, meters and telemetry)

6.4.1 Description

Regulator gates are a mix of vertical undershot and downward-opening gates that maintain upstream pool levels and ensure a constant flow is delivered to each farm. Offtake gates are upward-opening gates that regulate or isolate flow.

The Top Scheme has a total of 28 regulators and offtake gates (Figure 12). The Bottom Scheme has a total of 15 regulators and offtake gates (Figure 13 and Figure 14). These structures represent a mix of new and existing structures (Tables 19 to 22).

Depending on their location in the channel, regulators were fitted with single or dual gates, solar powered electric articulators, Motorola RTU flow measurement, upstream level sensors, gate position sensors and Observant telemetry systems.

Depending on their location in the channel, offtake gates were fitted with 1200 mm or 900 mm gates, solar powered electric articulators, MACE flow meters and Observant telemetry systems.

The two pump stations were also equipped with telemetry systems. These automated systems enables the Scheme Manager or other authorised personnel to monitor and control all pumps, regulators and offtakes from remote locations using a mobile phone or desktop computer. This system also accurately records water delivery data for analysis and invoicing.

Table 19: Regulators and fittings on Tenandra Top Scheme

Location	New gate	Level sensor	Position sensor	RTU flow measurement	Telemetry
Gum Swamp*	Yes	Yes	Yes		Yes
Collie Rd*	Yes	Yes	Yes		Yes
Five Ways*	Yes	Yes	Yes		Yes
Gibson's Lane*	Yes	Yes	Yes	Mace	Yes
Fernehurst/Bundah*	Yes	Yes	Yes		Yes
Junction	Yes	Yes	Yes	Yes	Yes
Milawa Branch*	Yes	Yes	Yes		Yes
Field 9A*	Yes	Yes	Yes		Yes
Clarendon (crossing)*	No	Yes	No		No
Milawa Reg	Yes	Yes	No		Yes
Kulkine	Yes	Yes	No		Yes
Myhree*	Yes	Yes	No		Yes

**New structures*

Table 20: Offtakes and fittings on Tenandra Top Scheme

Location	Gate	Actuator	Meter	Telemetry
Gum Swamp	Yes	Yes	Yes	Yes
Gilgai*	Yes	Yes	Yes	Yes
Paddy's River (upstream)*	Yes	Yes	Yes	Yes
Paddy's River (downstream)*	Yes	Yes	Yes	Yes
Moonbi*	Yes	Yes	Yes	Yes
Fernehurst*	Yes	Yes	Yes	Yes
Tenandra*	No	Yes	Yes	Yes
Old Bundemar*	Yes	Yes	Yes	Yes
McKay 1	Yes	Yes	Yes	Yes
Milawa F9*	Yes	Yes	Yes	Yes
Milawa F1	Yes	Yes	Yes	Yes
Tenandra West	No	Yes	Yes	Yes
Milawa F118	Yes	Yes	Yes	Yes
McKay 2	Yes	Yes	Yes	Yes
McKay 3*	Yes	Yes	Yes	Yes
Teasdale	Yes	Yes	Yes	Yes
Normandoon	Yes	Yes	Yes	Yes

**New structures*

Figure 12: Map showing channel structures on the Top Scheme

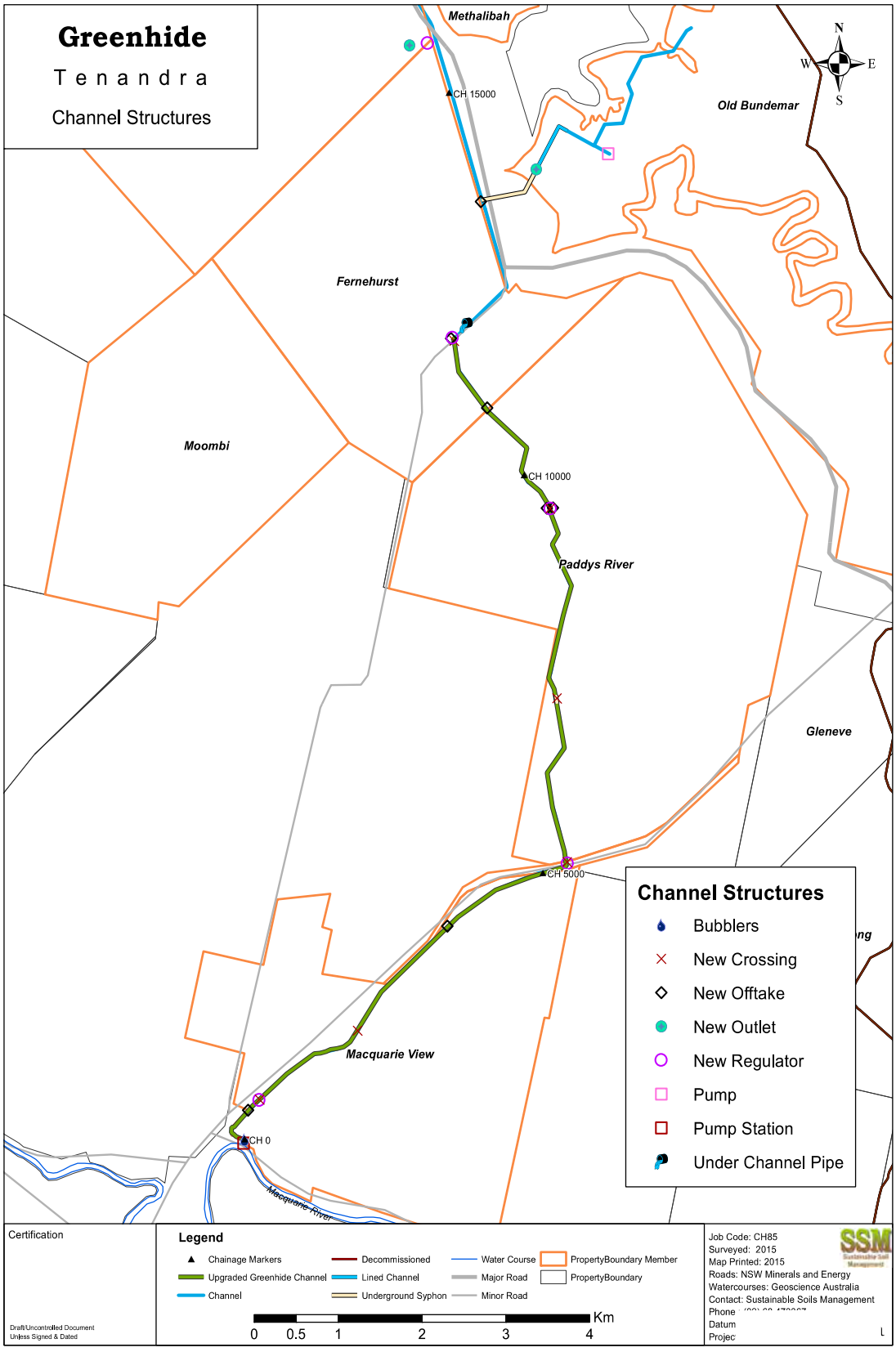


Table 21: Regulators and fittings on Tenandra Bottom Scheme

Location	New gate	Level sensor	Position sensor	RTU flow measurement	Telemetry
Ewenmar Creek*	Yes	No	No		Yes
Gillendoon*	Yes	No	No		Yes
The Cedars*	Yes	Yes	Yes		Yes
Hatton	Yes	Yes	Yes		Yes
Bellevue	Yes	Yes	Yes		Yes
Jedburgh	Yes	Yes	No		Yes
Drungalear Lane	Yes	Yes	Yes		Yes
Airlie*	No	Yes	No		Yes

**New structures*

Figure 13: A regulator on 'Hatton'. Depending on their location, regulators were fitted with single or dual gates, solar-powered electric articulators, Motorola RTU flow measurement, upstream level sensors, gate position sensors and Observant telemetry systems.

Table 22: Offtakes on Tenandra Bottom Scheme

Location	Gate	Actuator	Meter	Telemetry
Ewenmar Creek*	Yes	No	Yes	No
The Cedars*	No	No	Yes	Yes
Hatton*	Yes	Yes	Yes	Yes
Bellevue 1*	Yes	Yes	Yes	Yes
Bellevue 1*	Yes	Yes	Yes	Yes
Jedburgh	Yes	Yes	Yes	Yes
Glenrowan	Yes	Yes	Yes	Yes
Airlie*	Yes	Yes	Yes	Yes
Haddon Rig*	Yes	Yes	Yes	Yes

**New structures*

Figure 14: An offtake gate on 'Hatton'. Depending on their location in the channel, offtake gates were fitted with 1200 mm, 900 mm, 750 mm or 600 mm gates, solar-powered electric articulators, MACE flow meters and Observant telemetry systems.

Figure 15: Map showing channel structures on the southern end of the Bottom Scheme

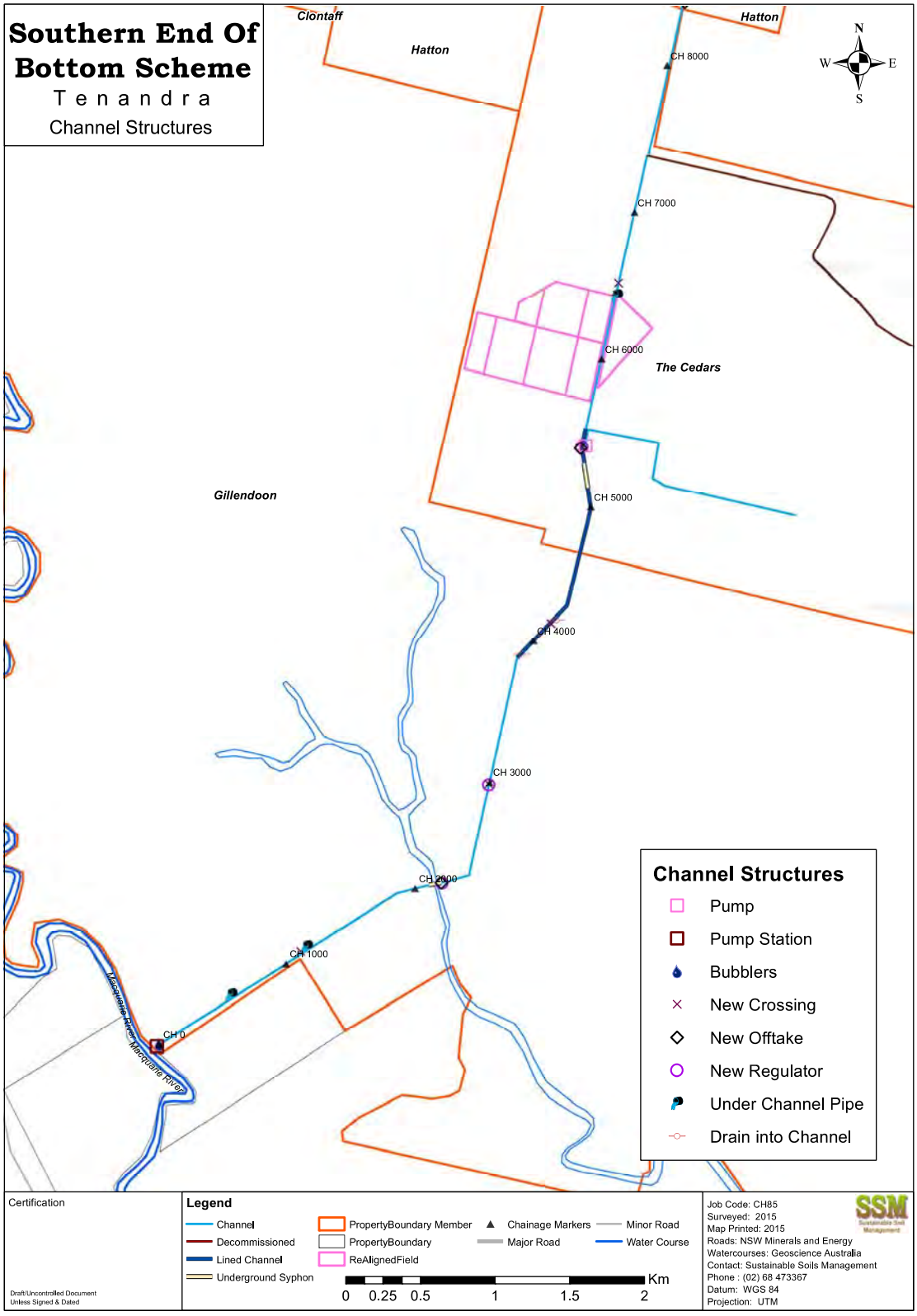
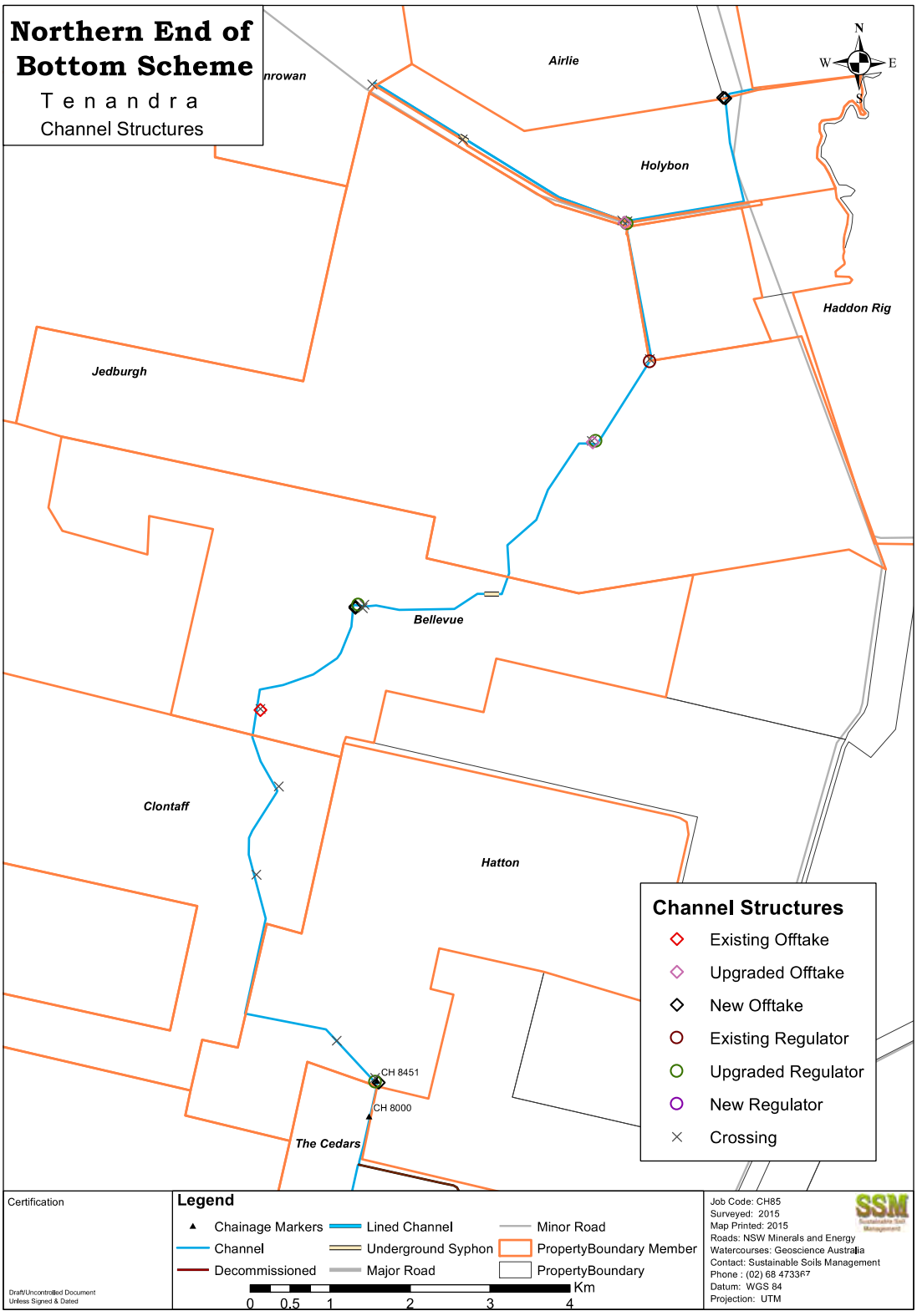


Figure 16: Map showing channel structures on the northern end of the Bottom Scheme



6.4.2 Key contractors

Contract 10-137 was awarded to AWMA Water Control Solutions, Cohuna, operating in partnership with DHI hydraulic modelling, Parasyn system engineers and Observant cloud-based monitoring and control platforms (Table 22).

Table 22: Summary of contractors and approximate contract value for siphon construction (Contract 10-129)

Contract	Contractor	Location	Service provided	Contract value (%)
10-137	AWMA Water Control Solutions	Cohuna Vic	System Design, Construction, and Installation	80%
	DHI Hydraulic Modelling			
	Parasyn System Engineers	Wantirna, Vic	Engineering	
	Observant	Melbourne, Vic	cloud-based monitoring and control platforms	20%

6.4.3 Budget

The funding agreement allocated a budget of $1,103,583 for channel controls (regulators, offtake gates, meters and telemetry), including design, certification, installation and commissioning. Final costs were $1,154,755 (Table 23), $51,172.00 (4.6%) over budget due to changes to the tendered design. These changes include the installation of automated ‘lay flat’ channel gates to existing channel structures and the installation of telemetry systems to the pump stations.

Table 23: Summary of budget and final costs (Contract 10-129)

Contract	Budget (ex GST)	Amount paid (ex GST)
Top Scheme	$689,539	$744,599.25
Bottom Scheme	$406,544	$402,655.75
Meter removal & install	$7,500	$7,500.00
Total	$1,103,583	$1,154,755

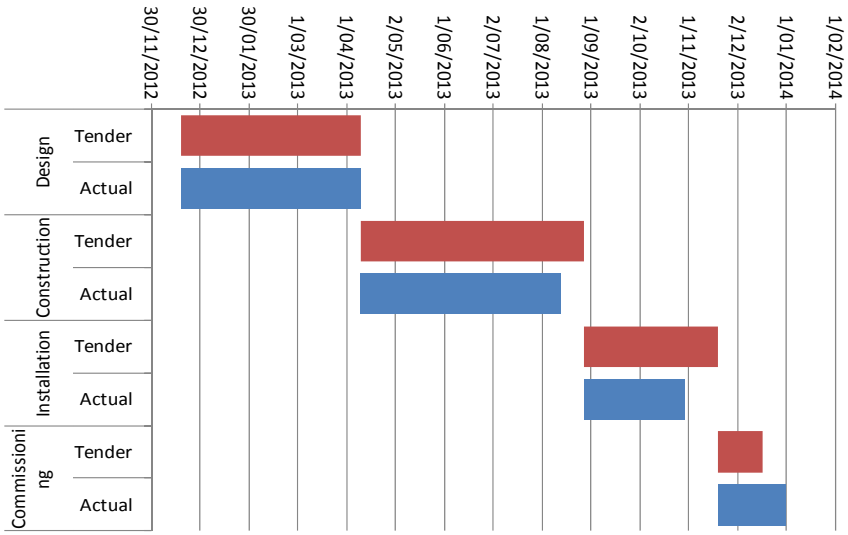
6.4.4 Managing claims

AWMA used a claims sheet to manage claims, whereby a percentage of the contracted amounts were claimed monthly as services were finalised or goods delivered. The claims were submitted for approval and then an invoice was raised. The claims sheet was updated at each claim, meaning Nejuru Pty Ltd and AWMA had full visibility of the current claim, historical claims, remaining contract value and deliverables outstanding. Claims were paid regularly once presented.

6.4.5 Time

The design and manufacture progressed as planned. Gates were delivered and stored at two locations on the Top and Bottom Scheme. The gates were installed as the sites became available. Commissioning was completed before the first irrigation. Fine-tuning of the software and performance continued during the irrigation season. The gate installation aligned well with the civil works and did not adversely affect the overall construction program.

Figure 17: Time taken to complete channel controls (Contract 10-137)



6.4.6 Quality assurance

AWMA developed and implemented a quality management system compliant with international standard ISO9001 (2008) (QEC24968) for the design, manufacture and installation of water control equipment. All gates and controls were manufactured and installed using ITP process, with checks applied at drawing, material picking, fabrication, fit out and before dispatch. No major quality issues were identified during this phase. Pre installation checks were conducted before installation. Some minor differences were identified between the ‘for construction’ civil works and ‘as built’ structures. These issues were either rectified or managed to ensure a compliant installation.

6.4.7 Work health and safety

AWMA developed and implemented an OH&S plan incorporating job site hazard reduction assessment, risk check list and site industry checklist. The work environment at times was challenging with the surrounding civil works in progress. This was well managed in conjunction with the civil sub-contractor.

6.4.8 Environment

AWMA's work on site for this project did not present any significant environmental risk. Gate installation involved working around newly-constructed channels rather than water or natural waterways. All chemicals used were suitable for use with potable water and all rubbish was removed from site. Gates were shipped on recycled wooden crates without plastic packaging materials.

6.5 Pumps and power

6.5.1 Description

Two new pump stations were constructed to transfer water from the Macquarie River to irrigators on the modernised Tenandra Scheme. This contract included new pumps, switching gear, foundations, discharge pipes and power. The switching gear for both pump stations is housed in 5 x 3 m steel sheds, which in turn, is enclosed by a 20 x 20 m fenced perimeter.

The existing Greenhide pump station was upgraded to convey a maximum capacity of 400 ML/day from the Macquarie River to irrigators along the combined Greenhide/Top Scheme. Works included the installation of:

- Two new 750 mm multi-stage axial flow pumps coupled to electric motors (one with variable frequency drive).
- New steel support piles for the two existing pumps.
- 60 metres of discharge pipes and headwalls/bubblers.
- New meters on all pumps.
- Supply and installation of 1500 KVA pad mount substation, including new power pole and high voltage cable from the pole to the substation.

Figure 18: Each of the two new 750 mm multi-stage axial flow pumps installed at Greenhide pump station has a capacity of 130 ML/day.

The combination of two new 130 ML/day pumps and two existing 70 ML/day pumps provides an operational capacity ranging from 20 ML/day to 400 ML/day with infinite increments.

In addition, a new pump station was constructed on 'Gillendoon' to convey a maximum capacity of 240 ML/day from the Macquarie River to irrigators along the Bottom Scheme. Works included the installation of:

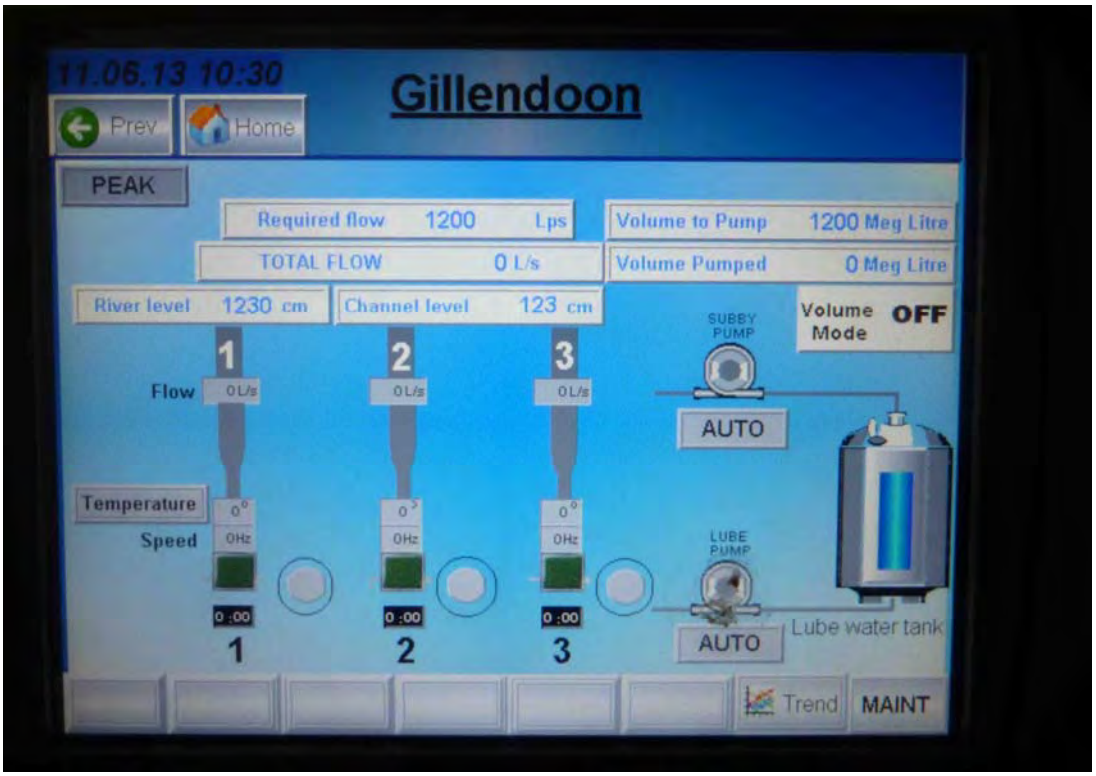
- Three new 630 mm multi-stage axial flow pumps (80 ML/day) coupled to electric motors (all with variable frequency drive).
- New discharge pipes and headwall/bubblers.
- New meters on all pumps.
- Supply and installation of 750 KVA pad mount substation, including new power pole and high voltage cable from the pole to the substation.

The three new 80 ML/day pumps provide an operational capacity of 20 ML/day to 240 ML/day.

Figure 19: The Gillendoon pump station features three new 630 mm multi-stage axial flow pumps (80 ML/day) with variable frequency drive.

Figure 20: The discharge bubblers at 'Gillendoon'.

Figure 21: Both pumping stations are equipped with automatic control systems with Next G and UHF telemetry.



6.5.2 Key contractors

Contract 10-128 for the design and construction of the pump sites was awarded to ICI Industries Pty Ltd (Irribiz), Griffith, NSW. Most components of this contract were provided by a range of local, regional and metropolitan suppliers (Table 24). Contract 10-136 for supply and installation of the new transformers and power supply was awarded to JLE Electrical in Dubbo.

Table 24: Summary of contractors and approximate contract value for installation of pumps and power (Contract 10-128) and new transformers and power supply (Contract 10-136)

Contract	Contractor	Location	Service provided	Contract value (%)
10-128	ICI Industries Pty Ltd (Irribiz)	Griffith, NSW	Head contractor	2%
	M & PM Oriel Pty Ltd	Warren, NSW	Installation of pile, cross rails and all structure works. Installation of poly pipework and bubblers associated with pump station and channel connection	20%
	WRL Engineering	Warren, NSW	Steel welding for structure supports	2%
	Batescrew pumps	Tocumwal, NSW	Supply and installation new pumps; assessment of the existing Greenhide pumps	22%
	Rod Thornton Electrical Contractors	Warren, NSW	Electrical works in conjunction with Ibis controls	12%
	Ibis Controls	Griffith, NSW	Supply and installation of all electrical works and telemetry	<1%
	Iplex Pipelines	Sydney, NSW	Supply of poly pipe	2%
	Rob Rye Irrigation	Shepparton, Vic	Supply of poly welding services	<1%
	Instant Screw Piling	Burleigh Heads, Qld	Engineering and supply of piles and steel works	<1%
	Mace Measuring and Control Equipment	Dural, NSW	Supply of water meters	<1%
	Custom Built Stainless	Griffith, NSW	Supply of walkways and platforms	1%
10-136	JLE	Dubbo, NSW	Supply of transformers, kiosks and platforms	32%
On-farm pumps	Fluid Engineering	Griffith	Supply of pumps to Old Bundemar and The Cedars	7%

6.5.3 Budget

The funding agreement allocated a budget of $3,200,284 for pumps and power. This amount was about 30% higher than original estimates due to major increases in power connections and the installation of two on-farm lift pumps. In addition, one of the pumps on the Top Scheme and all three pumps on the Bottom Scheme were re-specified with variable frequency drives. Both pump stations were fitted with power correction devices for improved flow rate accuracy and reduced power consumption. It is estimated that the power correctors will reduce electricity costs by about 7% per year. Final costs were $3,338,298.16, which is $138,014.16 (4.3%) over budget (Table 25).

Table 25: Summary of budget and final costs (Contract 10-128)

Contract		Budget (ex GST)	Amount paid (ex GST)
Pumps	Top Scheme (2 x 130 ML pumps)	$944,766.00	$995,104.12
	Top Scheme (repair existing pumps)	$65,210.00	$158,539.25
	Top Scheme (Old Bundemar lift pump)	$60,000.00	$95,104.60
	Bottom Scheme (3 x 80 ML pumps)	$923,313.00	$885,054.57
	Bottom Scheme (upgrade Noonan's lift Pump)	$90,000.00	$126,570.00
	Sub-total	**$2,083,289.00**	**$2,260,372.54**
Power	Top Scheme Transformer	$121,242.00	$197,125.00
	Top Scheme Power Infrastructure	$460,809.00	$403,569.97
	Bottom Scheme Transformer	$103,287.00	$192,491.00
	Bottom Scheme Power Infrastructure	$431,657.00	$284,739.65
	Sub-total	**$1,116,995.00**	**$1,077,925.62**
	Total	**$3,200,284.00**	**$3,338,298.16**

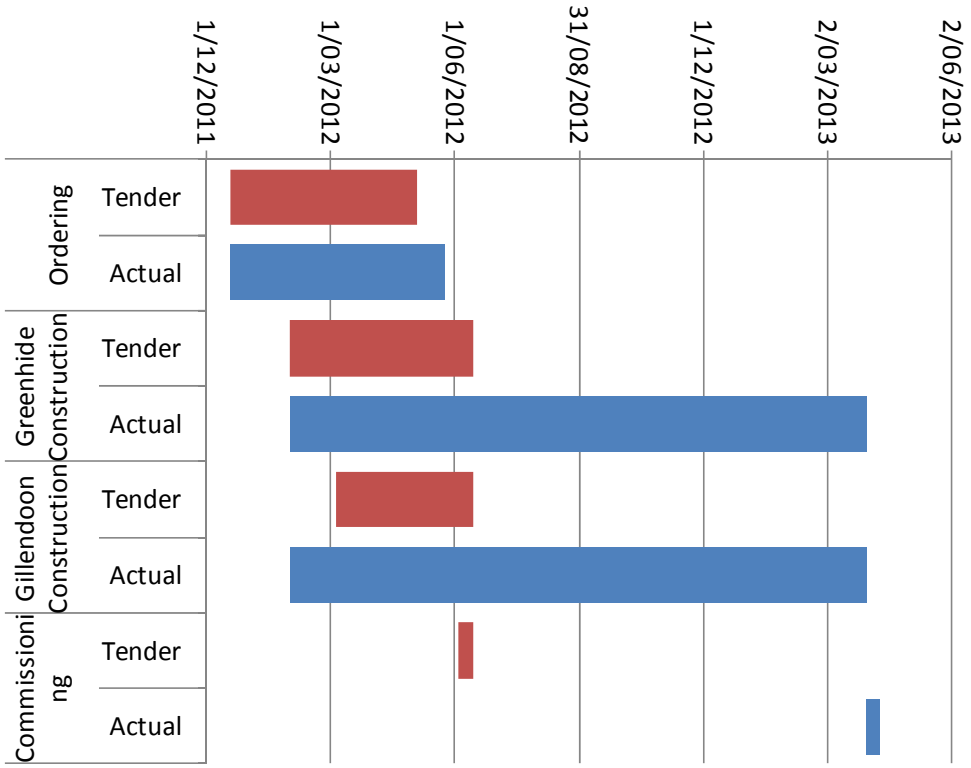
6.5.4 Managing claims

Progressive claims were lodged by the contractor during the constructive period. These claims were assessed, approved and paid as they became due.

6.5.5 Time

This project was considerably delayed by the need to upgrade the power supply to the Top Scheme pump station. However, this delay did not adversely impact the scheduled completion of the Modernisation Project due to extensive delays associated with the construction of the Top Scheme link channel. The Greenhide and Gillendoon pump stations were commissioned in June 2013.

Figure 22: Time taken to complete pump installation (Contract 10-128)



6.5.6 Quality assurance

The screw piles at Gillendoon and Greenhide pump sites were installed at no less than 100 kNm per pile and as per the design provided by Irribiz (M. Oriel, *pers comm*.). Opus International Consultants (PCA) Pty Ltd certified that the screw-in foundations have been designed to resist the stated loads in accordance with AS2159-2009 and AS4100. Narromine Shire Council was satisfied with the condition of Burroway Road pipeline crossing after the installation of the Greenhide pump station. No survey conformance report was obtained for the pumps, given that test specifications are stated in the design. This design also specified the torque required for screw piling. Compaction testing ensured the delivery pipes were installed within specification (Table 26).

Table 26: Compaction testing report for Greenhide and Gillendoon pump stations

Location	Test depth	Layer	Percentage compaction
Greenhide pump station, 12.5 m north of water meter	300 mm	Top of fill	98.5
Gillendoon pump station, 21 m to pump station	300 mm	Top of fill	97

6.5.7 Work health and safety

Irribiz developed and implemented a Work Health Safety and Environmental Management Plan (WHSEMP) to ensure compliance with relevant legislation and permit conditions. This plan required the completion of Occupational Health Safety and Environment (OHS&E) Site Hazard Inspection Reports. One OHS& E Site Hazard Inspection Report was completed during the project (Table 27).

Table 27: Summary of OHS&E Site hazard inspection report

Date	Issues raised	Controls required	Responsible
09/01/13	Missing tag on electrical lead	Tag missed however on register	WRL Engineering
	Visitors and other client members coming on site	Visitors to be stopped or accompanied by Irribiz supervisor	All Irribiz employees

6.5.8 Environment

Irribiz had a Work Health Safety and Environmental Management Plan (WHSEMP) in place for the construction of the two pump stations. The site WHSEMP was designed to ensure compliance with relevant WHS, Planning and Environmental legislation and permit conditions. Site inspections were conducted during the course of the project and no environmental issues were identified. No Incident/Accident Reports were completed in relation to the environment.

6.6 Fencing

6.6.1 Description

Approximately 20 km of fencing was constructed to prevent livestock access to new sections of channel in the Top and Bottom Schemes. A further 5 km of fencing was constructed to assist in the restoration of decommissioned channel to agricultural usage. The design of each section was determined in consultation with landholders and intended land usage. Chosen designs included hinge joint (mixed livestock), barbed wire (cattle) and electrified ‘Weston fence’ (livestock and feral animals). Pneumatically-driven intermediate posts were placed every 500 metres, with end-assemblies installed at the end of each section.

Figure 23: Approximately 25 km of fencing – such as this hinge joint fence and end-assembly – was constructed along new or decommissioned sections of channel.

Figure 24: Example of a 'Weston' fence assembly. The design of each section was determined in consultation with landholders and intended agricultural usage.

6.6.2 Key contractors

Quotes were requested from seven fencing contractors in central western NSW. Two contractors were selected on the basis of cost and availability. Shane Pettiford Fencing, Coonamble, was awarded the contract for the construction of 20 km of fencing along the new sections of the Top and Bottom Schemes. Bill O'Brien Fencing, Dubbo, was awarded the contract for the construction of 5 km fencing along decommissioned channel. Materials were procured by directly by Nejuru Pty Ltd from local rural supply centres, AGnVET, Warren, and Delta Ag, Trangie, using competitive quotes.

6.6.3 Budget

The funding agreement allocated a budget of $3,005,000 for fencing, including the construction of new fencing along the channel and reconnecting existing fences. The final amount was $357,125.42, or $52,125.42 (17%) over budget due to the mix of different designs, materials and gateways specified by each landholder.

Figure 25: Map showing location of fencing works on the Top Scheme.

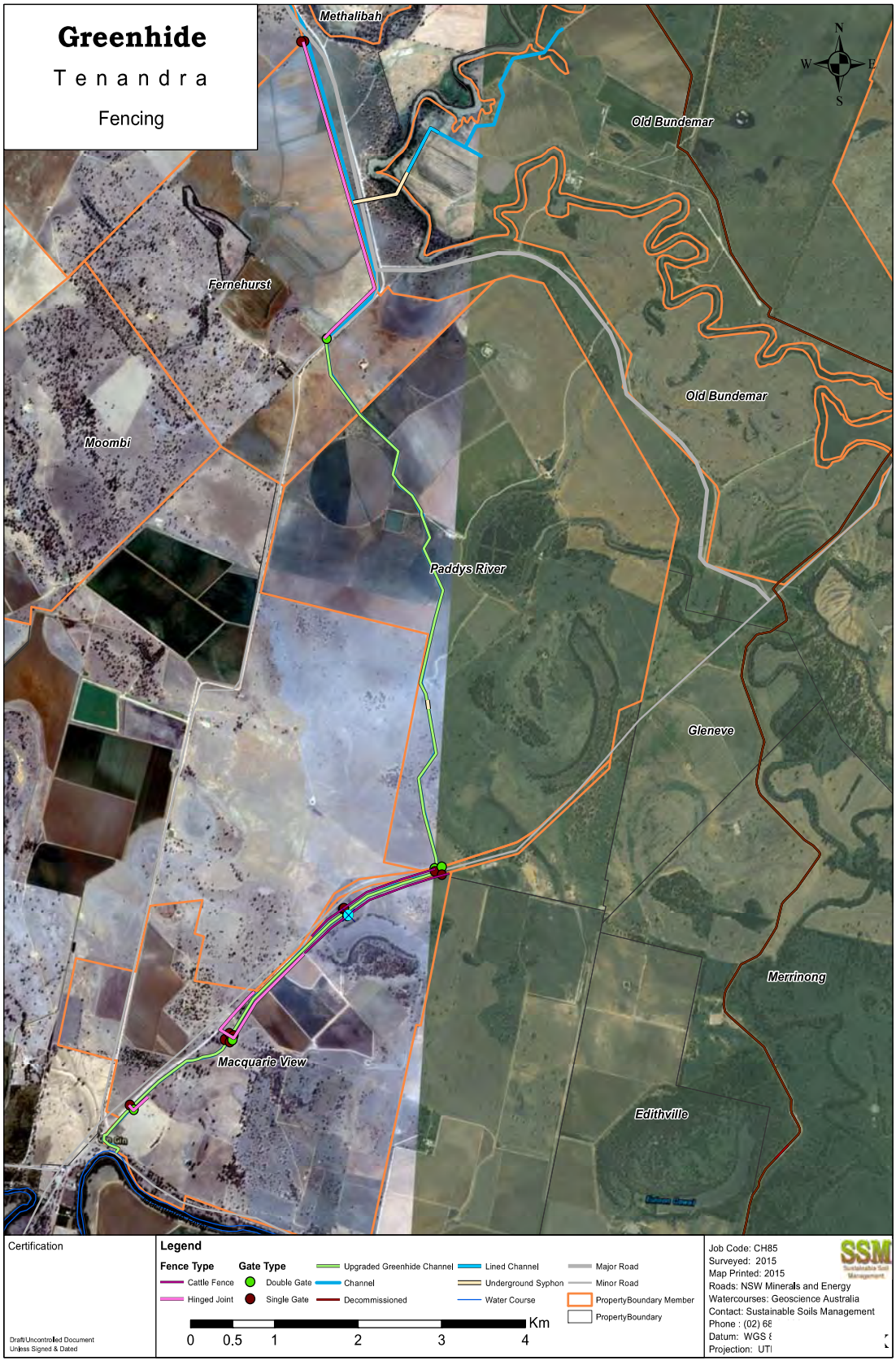
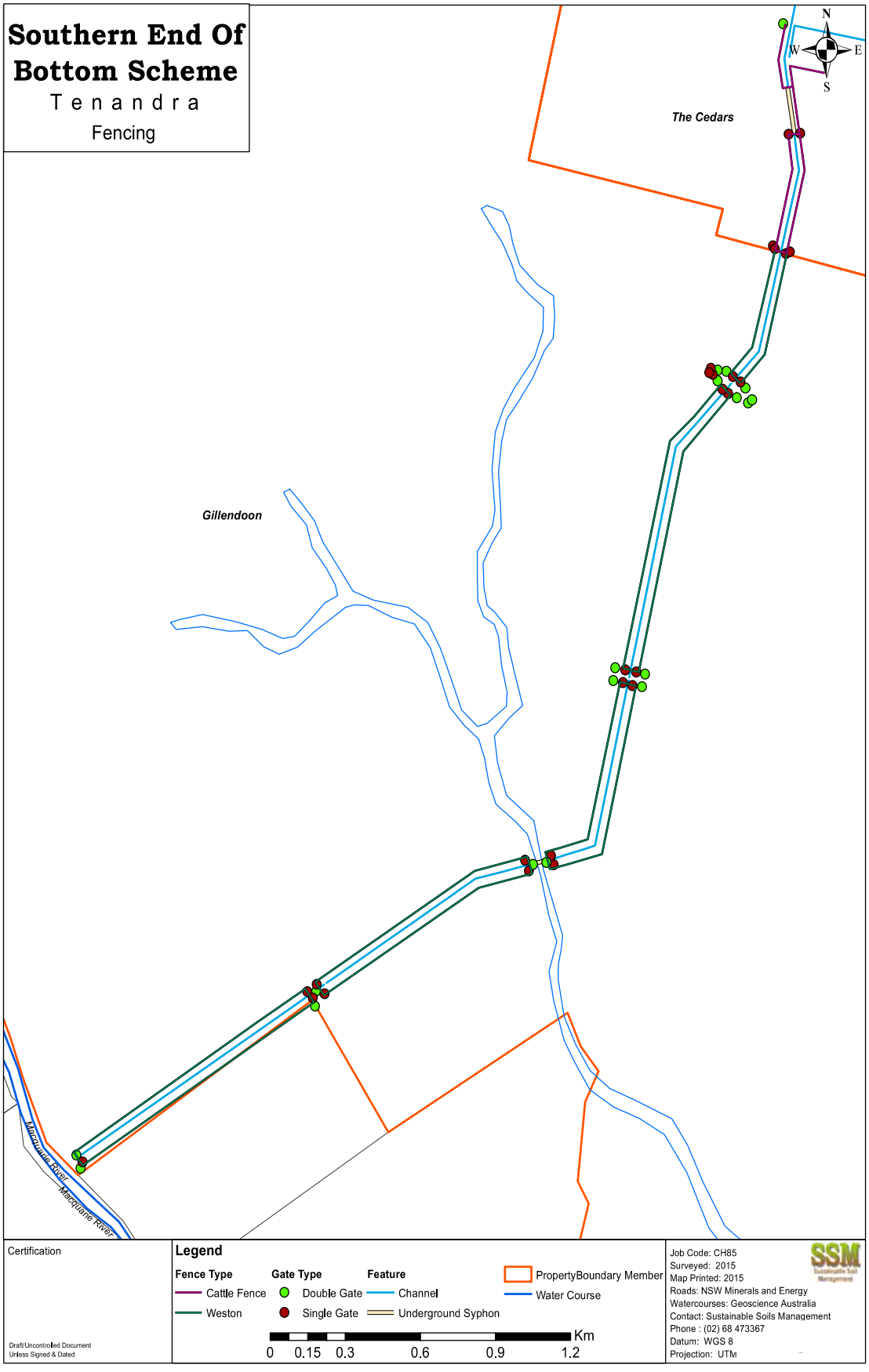


Figure 26: Map showing location of fencing works on the Bottom Scheme.



6.6.4 Managing claims

The two contractors were paid on completion of each job. All claims from contractors were paid in full during the construction phase of the project. Tax Invoices were processed and paid within 30 days of receipt.

6.6.5 Time

The fencing sub-project commenced once the construction of channels and associated structures had been completed. The first contract was completed in about four weeks. The second contract was completed in a week.

6.6.6 Quality assurance

Site Supervisor, Aaron Clifford, provided on-site supervision of the two contractors. Project Manager, David Duncan, Superintendent's Representative, Stephen Wonderley, and landholders inspected each section of fence upon completion.

6.6.7 Work health and safety

All on site contractors and workers adhered to best practice procedures for Work Health and Safety. No incidents were reported during construction.

6.6.8 Environment

Site inspections were conducted during the course of the project and no environmental issues were identified.

6.7 'Milawa' on-farm efficiency sub-project

6.7.1 Description

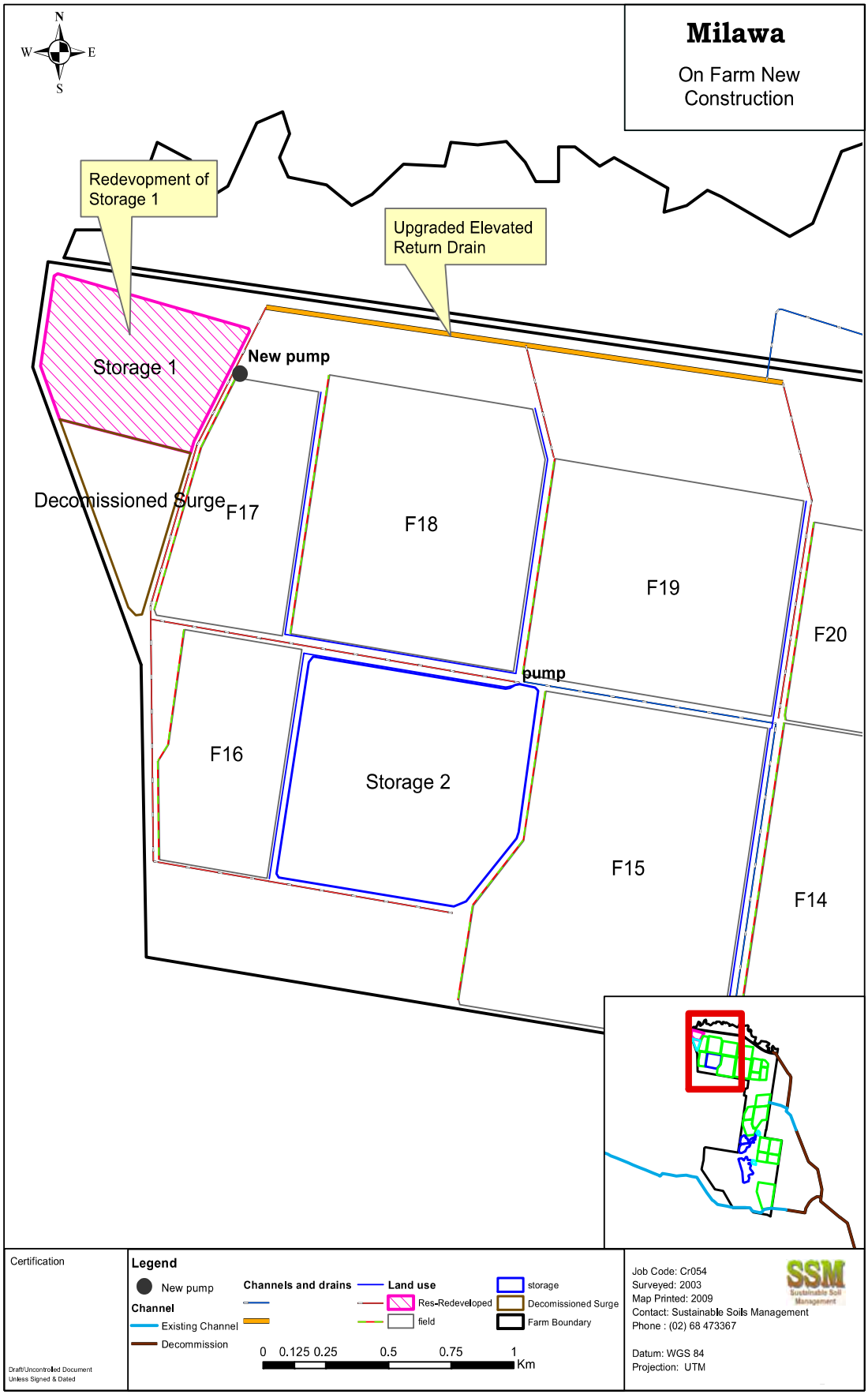
The PIIOP application contained a proposal from Milawa Pty Ltd to construct more efficient water storage facilities on the McAlary family property, 'Milawa'. This proposal included the division of a 75 ha ring tank (Storage 2) into two cells to allow the efficient storage and delivery of smaller volumes. The project was forecast to achieve water savings of about 408 ML ML/year, with 225 ML of these savings transferred to the Australian Government.

Due to wet weather, it became impractical to construct the planned works by the project deadline of June 2013. As such, an alternative program of on-farm modernisation works was submitted and approved by the Board. This revised proposal, which would achieve similar water savings as the original proposal, included:

- increasing the storage efficiency of a second reservoir (Storage 1) by increasing its bank height and reducing its surface area by 22 ha
- increasing the height of the supply channel from Storage 1
- construction of a new tailwater return system to Storage 1, and
- construction of a new pump station.

Figure 27: An aerial image of the upgraded Storage 1 on 'Milawa', which combined with other improvements to the supply channel, tailwater return and new pump station, resulted in water savings of about 408 ML/year. (© Bing)

Figure 28: Diagram of construction works undertaken on 'Milawa'.



6.7.2 Key contractors

The McAlary family managed this sub-project directly using devolved funding from the Commonwealth via Nejuru Pty Ltd. Principal contractors included P.J. & M.A. Kiem Partnership, Wee Waa (earthworks); BNB Engineering, Narrabri (steel pipe, gates and valves); Holcim Australia Pty Ltd (concrete pipes); and N.M. Owen Pty Ltd (fuel) (Table 28).

Table 28: Summary of contractors and contract value for 'Milawa' on-farm efficiency sub-project

Contractor	Location	Service provided	Contract value
Peter Leeson Pty Ltd	Goondiwindi, Qld	Surveying	$27,942.40
Barnson Pty Ltd	Dubbo, NSW	Compaction and density testing	$5,540.00
N.M. Owen Pty Ltd	Albert, NSW	Supply of diesel	$225,400.78
P.J. & M.A. Kiem Partnership	Wee Waa, NSW	Earthmoving /Construction	$445,495.80
Holcim Australia Pty Ltd (trading as Humes)	Tamworth, NSW	Supply of concrete pipes	$42,473.64
MAAS Plant Hire Pty Ltd	Dubbo, NSW	Supply of excavator	$35,328.00
BNB Engineering Pty Ltd	Narrabri, NSW	Supply of steel gates, valves and pipe	$76,871.40
National Plant and Equipment	Brisbane, Qld	Supply of compactor machine	$58,950.00
Cummins South Pacific Pty Ltd	Tamworth, NSW	Supply pump engine and parts	$26,847.62
Twin Disc (Pacific) Pty Ltd	Virginia, Qld	Supply pump parts	$475.27
G & L Barnett Earthmoving	Warren, NSW	Construction/earth moving Pump site	$84,810.36
Sustainable Soils Management Pty Ltd	Warren, NSW	Consultancy	$10,537.00
Camels Truck Repairs	Gilgandra, NSW	Pump preparation	$3,325.16
TOTAL			**$1,043,997.43**

Figure 29: Storage 1 prior to construction (left) and a cross section of the embankment during construction (right).

6.7.3 Budget

The funding agreement allocated a $562,880 for on-farm efficiency works on 'Milawa' in return for 225 ML of General Security water entitlements. The revised plan presented in December 2012 was expected to cost $711,000 to complete (Table 29). Final construction costs were $1,043,997.43, which is $332,997.43 above the revised budgeted cost and $481,197 above the amount of funding provided by the Commonwealth Government. This shortfall was met by Milawa Pty Ltd.

Table 29: Summary of budgeted, estimated and final costs for 'Milawa' on-farm efficiency sub-project

Works	Original proposal	Revised plan	Actual expense
Earthworks	$419,265	$413,000	$809,194
Supply and installation of pipes and gates	$143,616	$178,000	$119,345
New pump site, pump and motor		$120,000	$115,458
Total	$562,881	$711,000	$1,043,997

6.7.4 Managing claims

All claims from contractors were paid in full during the construction phase of the project by Milawa Pty Ltd. Tax invoices were processed and paid within 30 days of receipt. At the completion of the works, Milawa Pty Ltd made a claim to Nejuru Pty Ltd for the Commonwealth contribution of $562,800.

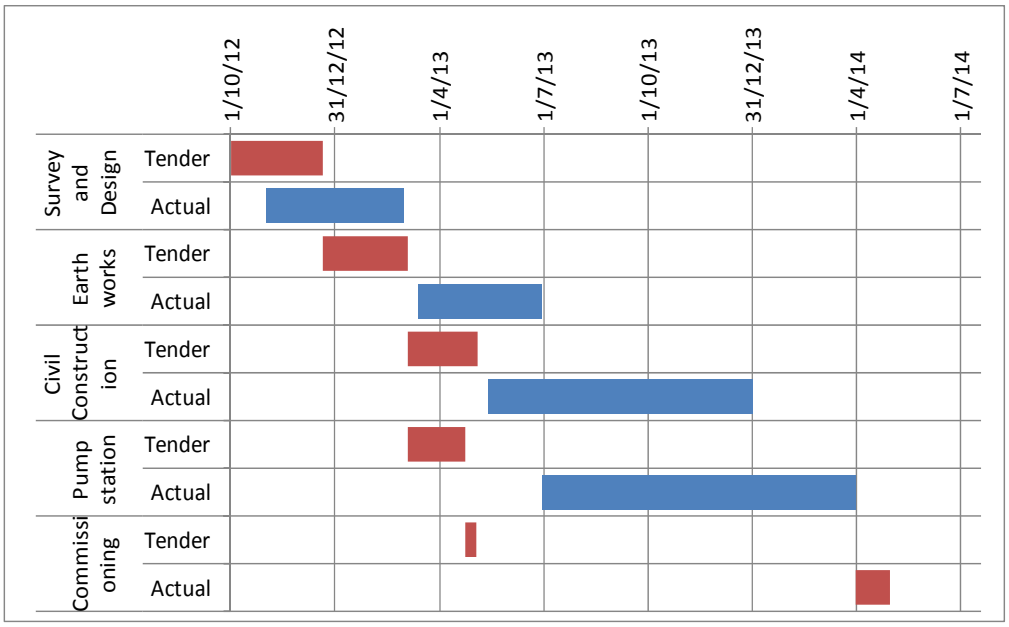
6.7.5 Time

The project took a total of 15 months to complete. Survey and design was undertaken in October and November in 2012 and earthworks commenced in March 2013. The project was delayed due to extended rain and wet periods halting earthworks (Figure 30). Final pump site was finished in March 2014 (Figure 31).

Figure 30: Heavy rain followed by a wetter than normal winter delayed completion of earthworks

Figure 31: Construction operations of 'Milawa' on-farm efficiency sub-project

Figure 32: Timeline to complete 'Milawa' on-farm efficiency sub-project



6.7.6 Quality assurance

The Project Manager, Sustainable Soils Management Pty Ltd, inspected earthworks on 11 occasions between March and May of 2013. Barnson Pty Ltd performed six bulk density tests and moisture tests throughout construction to ensure that compaction was meeting or exceeding the contract specification of 98% maximum dry density.

Test sites were located near the centreline of the embankment. Tests were conducted near the base (1.0 m), middle (3.0 m) and top of the embankment (4.5 m). With the exception of one sample, these test results indicated that the embankment was constructed to specification at all locations. As the natural moisture content declined to around 10% below optimum during construction, additional water was applied to condition the clay material to ensure adequate compaction was achieved. Subsequent testing showed compaction results continued to exceed specification.

6.7.7 Work health and safety issues

All on site contractors and workers adhered to best practice procedures for Work Health and Safety. No Incident/Accident Reports were completed.

6.7.8 Environment

Site inspections were conducted during the course of the project and no environmental issues were identified. All incident/accidents and near misses were required to be reported to the Project Manager. No Incident/Accident Reports were completed in relation to the environment.

6.8 'Bellevue' on-farm efficiency sub-project

6.8.1 Description

The PIIOP application contained a proposal from Hatton Grazing Co Pty Ltd to construct a new clay-lined delivery channel and other improvements to the existing sub-surface irrigation system on the Hatton Partnership property, 'Bellevue'.

The new supply channel is designed to convey irrigation water from the Tenandra Scheme channel to the main reservoir on Bellevue and to return water from the reservoir to Field 17 and the drip station near the Bellevue Offtake from the Scheme channel. Water can also be fed from the Tenandra Scheme channel directly to the fields. The works on the Bellevue supply channel required a new head ditch to be constructed beside the new supply channel.

The ability to supply gravity-fed water to all fields means smaller volumes of water can be held in the supply channel and fed directly into the sub-surface irrigation system without having to pump water into on-farm storage. The proposed improvements to the supply, control and management of water were estimated to achieve water savings of 311 ML/year (Table 30), with 160 ML of these savings transferred to the Australian Government.

Table 30: Proposed works, benefits, water savings and costs of 'Bellevue' on-farm efficiency sub-project

Improvement	Benefit	Water saving	Cost
Re-build and clay-line supply channel	• Gravity supply to all fields • Reduced pumping costs	118 ML	$385,000
Upgrade control system	• Maximise water efficiency	58 ML	$ 15,000
Install ring feed for Field 17	• Increase uniformity of irrigation	15 ML	$ 15,000
Improvement on-farm water management	• Reduction in storage evaporation	120 ML	Nil
Total		311 ML	$415,000

Figure 33: The construction of a new moisture compacted, clay-lined delivery channel and improvements to the existing drip irrigation system on 'Bellevue' resulted in water savings of 311 ML/year. (© Bing).

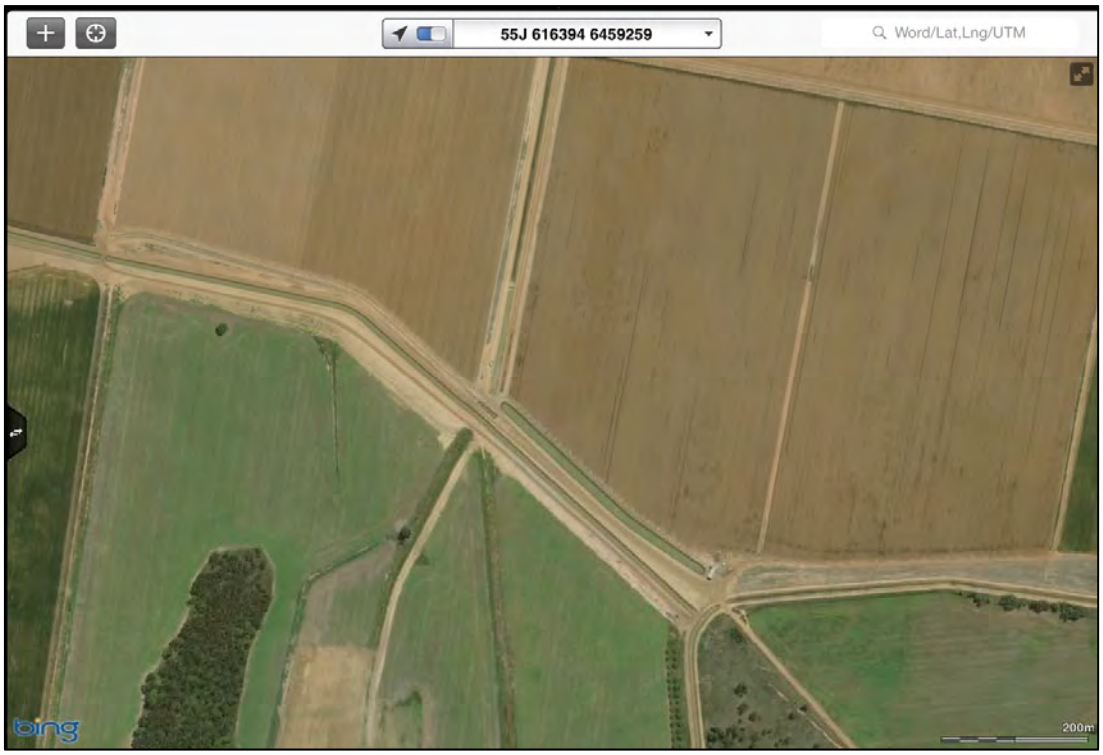
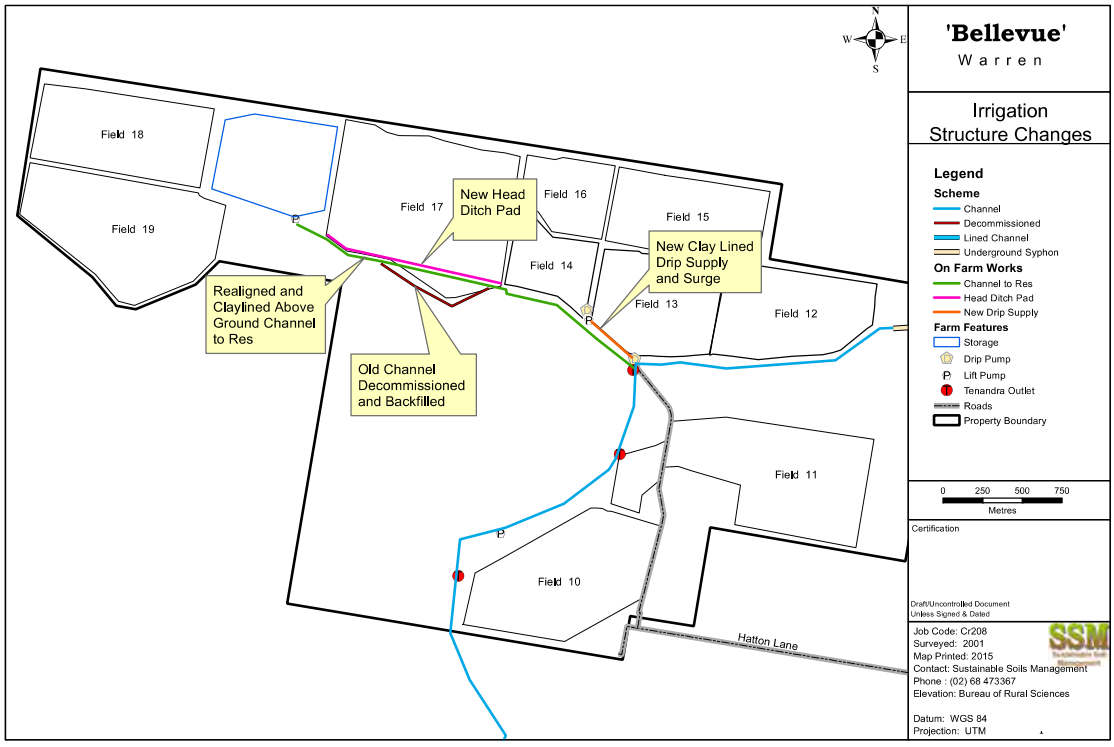


Figure 34: Diagram of construction works undertaken on 'Bellevue'.



6.8.2 Key contractors

The Hatton Grazing Co Pty Ltd managed this sub-project directly using a design prepared by SMK Consultants, Moree, with earthworks completed by SJ McCutcheon & Sons, Narromine. Steel pipe was supplied direct from East Coast Pipe Supplies and concrete pipe and headwalls was supplied by Bruno Altin & Co, Griffith. Modifications to the drip system were completed by Darling Irrigation, Narromine. NM Owen Pty Ltd provided fuel for the earthworks (Table 31).

Table 31: Key contractors used during 'Bellevue' on-farm efficiency sub-project

Contractor	Location	Service Provided	Contract Value Ex GST
S.J. McCutcheon & Sons	Narromine, NSW	Channel and head ditch construction and installation of pipes	$310,120.00
Darling Irrigation	Narromine, NSW	Supply and installation of drip pump upgrades	$29,759.42
SMK Consultants	Moree, NSW	Channel and head ditch design	$10,981.03
East Coast Pipe Supplies	Zillmere, QLD	Supply of steel pipe	$76,353.32
Bruno Altin & Co Pty Ltd	Griffith, NSW	Supply of concrete headwalls and pipe	$19,866.39
N.M. Owen Pty Ltd	Albert, NSW	Supply of fuel	$78,199.73
Total			$525,299.39

6.8.3 Budget

The funding agreement allocated a budget of $400,000 for the on-farm modernisation projects on 'Bellevue' in return for the transfer of 160 ML of water entitlements to the Commonwealth. Due to cost overruns, the entire funding was spent during the construction of the supply channel and head ditch. The wet subsoil under the supply channel had to be excavated, and dry soil spread on top with a bulldozer until it could be driven on with a scraper. Final construction costs, including the construction of the supply channel, modifications to the reservoir and adjoining fields and the construction of the clay-lined supply for the drip pump, was $525,299.39 (Table 32). Hatton Grazing Co Pty Ltd funded the shortfall in funding.

Table 32: Breakdown of costs for the 'Bellevue' on-farm efficiency sub-project

	Budget (ex GST)	Actual cost (ex GST)
Re-build and clay line supply system	$385,000	$399,329.26
Design		$11,000.53
Fuel		$78,199.73
Earthmoving		$310,120.00
Pipes and headwalls		$96,219.71
Drip system modifications	$15,000	$29,759.42
Install ring feed	$15,000	
Total	$415,000	$525,299.39

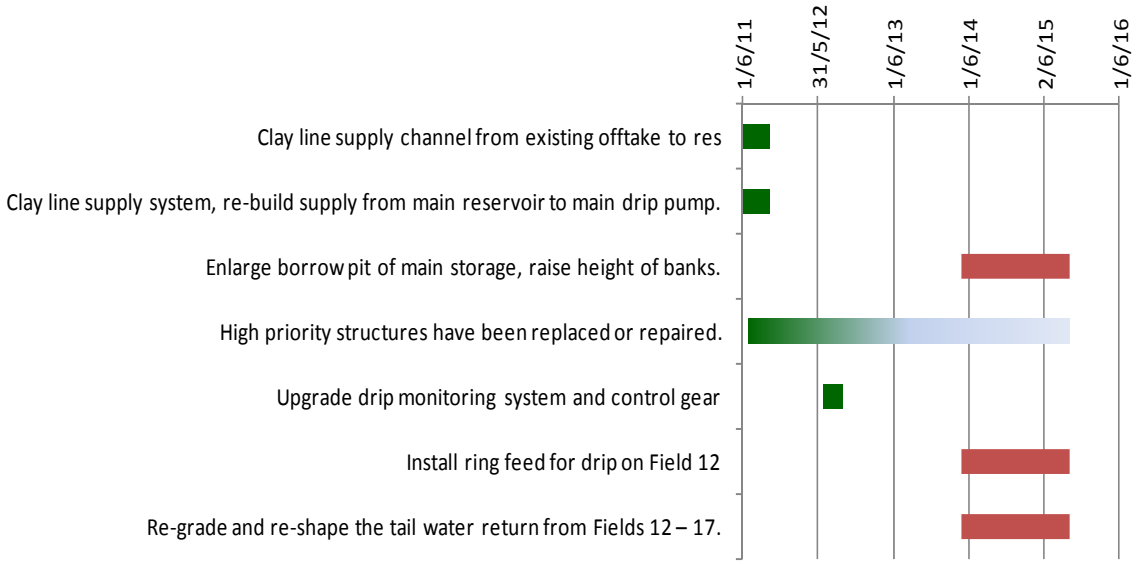
6.8.4 Managing claims

All claims from contractors were paid in full during the construction phase of the project by Hatton Grazing Co Pty Ltd. Tax invoices were processed and paid within 30 days of receipt. At the completion of the works, Hatton Grazing Co Pty Ltd made a claim on Nejuru for the Commonwealth contribution of $400,000.

6.8.5 Time

Clay-lining of the 'Bellevue' supply channel was completed in October 2011, and modifications to the drip system were completed in November 2011 (Figure 34). The installation of the ring main for the drip system and reshaping of the tailwater returns will be completed by Hatton Grazing Co when cash flow permits to achieve the remainder of the planned water savings.

Figure 35: Time taken to Bellevue on-farm efficiency project



6.8.6 Quality assurance

Seepage tests were completed on various channels around the farm as part of a whole farm water balance in February 2014. This showed the clay-lined channel to have a seepage rate of 8 mm/day compared to 38 mm/day for unlined channels on the property. Water balance analysis conducted by Sustainable Soils Management Pty Ltd has confirmed the new channel achieved water savings of 138 ML in 2011/12 (Table 33). The ability to supply gravity-fed water to all paddocks has greatly reduced the need for on-farm storage, resulting in significant water savings from reduced evaporation, as well as reduced pumping costs.

Table 33: Changes to layout and losses as a result of system upgrades on "Bellevue".

		Old channel	New channel
Infrastructure	Length (m)	2400	2370
	Width (m)	5	10
	Area (ha)	1.2	2.4
	Daily seepage (mm/day)	60	2
	Season net evaporation (mm)	386	386
	Season length (days)	182	182
Water usage ML/year	Seepage losses (ML)	131	9
	Evaporation losses (ML)	5	9
	Operational losses (ML)	20	0
	Total losses	156	18
Fuel consumption Litres/year		60,000	30,000

6.8.7 Work health and safety issues

S.J. McCutcheon & Sons had a Safety Management Plan (SMP) in place for the construction of the supply channel. The site SMP was designed to ensure compliance with relevant WHS, Planning and Environmental legislation and permit conditions. All relevant Safety Policies & Checklists were identified. No Incident/Accident Reports were completed.

6.8.8 Environment

Site inspections were conducted during the course of the project and no environmental issues were identified. All incident/accidents and near misses were required to be reported to the Project Manager. No Incident/Accident Reports were completed in relation to the environment.

6.9 'Old Bundemar' on-farm efficiency sub-project

6.9.1 Description

The PIIOP application contained a proposal by Bydand Holdings Pty Ltd to construct a new centre pivot irrigator, pump station and associated plumbing for a second irrigated circle on the field adjacent to the present Tenandra Channel on 'Old Bundemar'. At the time, more than 1,175 ha had been developed to lateral move, centre pivot and border check irrigation systems utilising water entitlements from the Tenandra Scheme, the former Greenhide Scheme and Ewenmar Creek. These entitlements were used to produce a range of cotton, winter cereals and forage crops.

The PIIOP application contained a proposal to convert 148 ha of border check irrigation to centre pivot irrigation on 'Old Bundemar'. This sub-project was pivotal to the success of the entire Modernisation Project, as the reconfigured Top Scheme by-passes through existing irrigation development on 'Old Bundemar'. In addition, 10 km of the upgraded Greenhide channel and new Top Scheme link channel run through two other Hassad Australia properties, 'Paddy's River' and 'Fernehurst' that are part of the Old Bundemar Aggregation.

Bydand Holdings proposed to install a 50 ha centre pivot irrigator to replace two fields developed to border check irrigation on 'Old Bundemar'. The proposed improvements were forecast to achieve water savings of 140 ML/year (Table 35), with all of these saving transferred to the Australian Government in return for $350,000 in funding.

Additionally, Bydand planned to self-fund the installation of a second 77 ha centre pivot irrigator on an existing pad in 'Paddy's River'. The installation of the two centre pivot systems would allow Bydand to significantly improve its water use efficiency, particularly in low water availability years and provide greater flexibility in its cropping options.

After the initial planning and funding agreement, 'Old Bundemar' was sold to Hassad Australia and all agreements and commitments made by Bydand Holdings relating to the Tenandra Scheme PIIOP agreement were transferred to Hassad Australia.

Hassad Australia installed the planned 50 ha centre pivot irrigator, modified the border check head ditch and decommissioned the delivery pipes. The return drain was also upgraded to improve tailwater recycling and to integrate the new supply channel from the new 'Old Bundemar' offtake from the new Scheme link channel. In addition, the existing linear move irrigator was upgraded with water efficient nozzles and the pump at the 'Paddy's River' pivot was upgraded with an energy efficient filtration system.

Prior to Modernisation, Bydand Holdings were planning to reduce the irrigation on Old Bundemar and committed the rationalisation of 2,500 ML of water to the project. After the purchase of Old Bundemar by Hassad, they too were contemplating winding back irrigation on the Old Bundemar Aggregation (T McKeon, pers comm.). Since modernisation of the Scheme, Hasad management have seen the benefits of the scheme works and Hassad plan to continue the conversion of its 'Paddy's River' and

'Fernehurst' properties to modern water efficient irrigation systems. They have recently spent almost $1million rebuilding a damaged weir and water storage on Old Bundemar.

Figure 36: The conversion of 148 ha of border check irrigation to centre pivot irrigation on 'Old Bundemar' resulted in water savings about 140 ML/year.

6.9.2 Key contractors

Hassad Australia managed this sub-project directly using devolved funding from the Commonwealth via Nejuru Pty Ltd. Aquawest Pty Ltd, Dubbo, was the main supplier, with DJ & LE Anning, Narromine, providing machinery and operators for the earthworks.

6.9.3 Budget

The original proposal to install the two new centre pivots on 'Old Bundemar' and 'Paddy's River' was estimated to cost $472,842 (Table 34). An amount of $350,000 was received from the Commonwealth to fund this project. Additional costs were funded by Hassad Australia, partially via the transfer of 2,250 ML of rationalised water entitlements to the Commonwealth.

Table 34: Proposed works, benefits, water savings and costs of 'Old Bundemar' on-farm efficiency sub-project

Improvement	Water saving	Budget	Actual
Reconfigure supply channels and drainage			$43587.50
Install 50 ha centre pivot irrigator, including plumbing for a second circle		$320,325	$279,962.22
Install 77 ha centre pivot irrigator		$152,517	0
Efficiency upgrades to pivots and lateral			$32,926.67
Total	140 ML	$472,842	$356,476.59

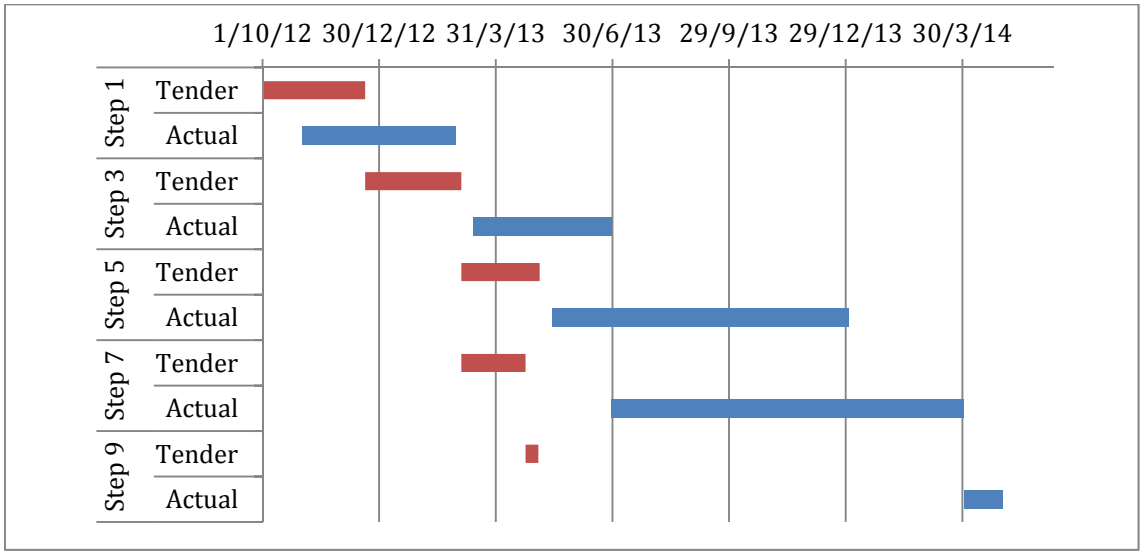
6.9.4 Managing claims

All claims from contractors were paid in full during the construction phase of the project by Hassad Australia. Tax invoices were processed and paid within 30 days of receipt. At the completion of the works, Hassad Australia made claims on Nejuru for the Commonwealth contribution of $350,000.

6.9.5 Time

The 'Old Bundemar' on-farm efficiency sub-project commenced in October 2012 and was completed in April 2014, 12 months behind schedule (Figure 36).

Figure 37: Timeline to complete 'Old Bundemar' on-farm efficiency sub-project



6.9.6 Quality assurance

Site inspections were conducted during the course of the project and no environmental issues were identified. All incident/accidents and near misses were required to be reported to the Project Manager. No Incident/Accident Reports were completed in relation to the environment.

6.9.7 Work health and safety issues

Hassad Australia applied in-house HSE policy consistent with Nejuru's HSE plan. All on site contractors and workers adhered to best practice procedures for Work Health and Safety. No Incident/Accident Reports were completed.

6.9.8 Environment

Site inspections were conducted during the course of the project and no environmental issues were identified. All incident/accidents and near misses were required to be reported to the Project Manager. No Incident/Accident Reports were completed in relation to the environment.

6.10 Decommissioning

6.10.1 Description

Splitting the Tenandra Scheme into two channels meant that a significant length of former main and branch channel was no longer required to efficiently deliver water to remaining members along the Top and Bottom Schemes. More than 50 km of former main and branch channels over 14 landholdings were decommissioned.

Embankments on either side of the channels were pushed in or spread using hired Caterpillar D10 and D8 bulldozers. Channels were back-filled using material sourced on-site or to a maximum of two kilometres away. Topsoil, where available, was spread over the top. A laser bucket was then used to level the disturbed area. A number of culverts and an inverted Siphon under Ewenmar Creek under Collie Road were also removed or plugged, and the site was backfilled to the level of the table drain of the road and natural surface. Some concrete structures were left intact at the request of landholders.

It was estimated that the removal, disposal and rehabilitation of the Tenandra pump station and decommissioning the first 2300 metres of the former Bottom Scheme channel would have cost approximately $250,000. A 900-metre section of this channel (Chinaman's Cutting) sits on Public Land and has historical significance, having been dug by Chinese workers in the 1890s.

As such, this infrastructure was left intact to enable the adjoining landholder, who is not a member of the Tenandra Scheme, to utilise these facilities to deliver riparian water entitlements. The permissive occupancy tenure for this land and Works Authority for the pump site will be transferred to the adjoining landholder.

Two channel crossings under the Oxley Highway will be filled with concrete by Roads and Maritime Services (RMS) and the site restored. Nejuru Pty Ltd has agreed to pay RMS $20,000 toward the cost of $40,600 to complete these works.

6.10.2 Key contractors

Two Caterpillar D10 and D8 bulldozers were hired from Goodsell Machinery & Hire, Parkes. Nejuru Pty Ltd directly employed two experienced plant operators, as well as supplying supplied fuel and insurance. This procurement model proved to be very cost-effective, with the total cost of $0.70 per cubic metre representing less than one third of standard commercial rates. Levelling/finishing work was performed by Clint Heterick, Maitland, at a flat rate of $200/hour.

Warren Shire Council has been contracted by RMS to complete the decommissioning of the Oxley Highway crossings. This work will be undertaken when conditions allow. D. & R. Oriel plugged and backfilled the Collie Road and Quambone Road crossings.

Figure 38: Quambone Road crossing approximately 12 months after decommissioning.

Figure 39: Looking west across the decommissioned Quambone Road crossing and along the decommissioned Scheme channel in "The Cedars", approximately 60 km downstream of the Tenandra pump site.

Figure 40: Backfilling operations on a section of decommissioned main channel on 'Edithville'.

Figure 41: After five passes with a laser bucket the area was left flat and smooth.

6.10.3 Budget

The funding agreement allocated a budget of $850,000 for decommissioning works. The scope of works for decommissioning was significantly reduced to $550,722 to offset increased channel construction and project management costs (Table 35). However, the use of 'dry hire' machinery allowed Nejuru Pty Ltd to significantly reduce decommissioning costs without impacting outcome.

Table 35: Budget for decommissioning

Improvement	Budget	Total Cost
Channel decommissioning	$650,000	$491,246.75
Structure removal	$200,000	$ 59,525.44
Total	$850,000	$550,772.19

6.10.4 Managing claims

All claims from contractors were paid in full during the decommissioning phase of the project. Tax Invoices were processed and paid within 30 days of receipt. Wages were paid fortnightly to machinery operators.

6.10.5 Time

Decommissioning started in July 2014 and was completed by October 2014. Depending on the conditions, the channels were filled in at a rate of 300 to 1500 metres per day.

6.10.6 Quality assurance

Decommissioning works were managed directly by the Board's sub-committee in consultation with Project Manager, David Duncan; Superintendent's Representative, Stephen Wonderley; Site Supervisor, Aaron Clifford; and landholders.

6.10.7 Work health and safety issues

The Project Manager developed and implemented a Work Health and Safety plan. No Incident/Accident Reports were completed. A 'tool box' meeting was conducted with contractors at the commencement of this sub-project as the equipment entered a new property or section. Lyntet Communications, Dubbo, provided cable locations while landholders pegged known pipelines.

6.10.8 Environment

Site inspections were conducted during the course of the project and no environmental issues were identified. The filled-in channels pose no risk to humans, livestock or the environment. In most cases, the restorative earthworks have been left slightly domed to allow for subsidence. In some sections, there was insufficient material available to achieve a complete fill. Any depressions have been interspersed with 'crowns' to facilitate fencing or thoroughfare and left open at their lower ends to disperse water. In time, it is expected that groundcover will rejuvenate naturally to a mix of native species similar to that found on undisturbed pastoral land. Further works may be required at a later date to re-establish ground cover, repair settlement or prevent erosion.

6.11 Establishment of Loss Water Access Licence (WAL), rationalisation and transfer of water entitlements

6.11.1 Background

Water is delivered to each member according to their entitlement and the seasonal allocation. Members can supplement their allocation with whatever other permanent or temporary water entitlements they may hold. Alternatively, Member can opt to 'carry over' their allocation to the next season or to sell their allocation to other Members.

Prior to the Modernisation Project, the Tenandra Scheme held a General Security Water Entitlement Licence (WAL) of 28,056 ML and a Supplementary WAL of 1,263 ML. Five members held other General Security licences totalling 5,518 ML that were delivered via the Tenandra Scheme. In addition, four members held General Security, Supplementary and High Security entitlements totalling 12,883 ML that were not attached to Scheme.

6.11.2 Delivery and Operating & Maintenance costs

Members have priority for all water deliveries. Members are invoiced monthly for the amount of water used in the previous month and their proportion of pumping costs. In addition, Members are invoiced monthly for operating and maintenance (O&M) costs, regardless of the amount of water delivered or the allocation. The latter is determined by the Scheme Committee based on an annual review of channel infrastructure and forecast expenditure.

Temporary users are charged for delivery costs, as well as an operating and maintenance charge per megalitre delivered. Members and temporary users who are in arrears in relation to their O&M charges are levied 12% interest per annum for the first month and 18% for every month thereafter. Water is not delivered to any Scheme user who is in arrears for more than 90 days.

6.11.3 Creation of Loss Water Access Licence

A pivotal part of the Tenandra Modernisation Project was the creation of a 'Loss' WAL, a mechanism that would enable Members who wished to exit the Scheme to sell some or all of their entitlement on the open market whilst maintaining the viability of the Scheme for the remaining members.

In 2009, Members voted unanimously to change the Scheme's constitution to introduce termination fees. This change was necessary to comply with the Australian Consumer Competition Committee (ACCC) rules to allow free trade of water. Under these changes, Members who permanently transferred some or all of their water entitlements off the Scheme had to pay a termination fee equal to 10 times the annual operating and maintenance charge for the current year. In addition, 10.36% of the entitlement being transferred had to be transferred to Tenandra Scheme's Loss WAL. These termination fees were calculated in accordance with the Water Charge (Termination Fees) Rules 2009.

The Scheme members committed 13,894 ML of General Security water entitlements to the Modernisation Project via rationalisation, exiting members and on-farm efficiency works. The Loss WAL was created from the retention of 10% of this water or 1,390 ML, with the balance 12,504 ML (90%) returned to the Commonwealth.

The Loss WAL, which is owned by Nejuru Pty Ltd, ensures sufficient water remains in the Scheme to enable the efficient delivery of water to the remaining members.

Depending on the season, Nejuru Pty Ltd can opt to transfer this entitlement to the Scheme WAL to offset losses to evaporation or seepage. Tenandra is believed to be the first privately-owned irrigation scheme that has elected to establish a Loss WAL.

6.11.4 Rationalisation process

Members who elected to provide some or all their water entitlements as part of the Tenandra Scheme Modernisation Project entered into individual agreements with the Scheme, which were tied to the funding agreement with the Commonwealth.

A total of 12 Members, including six with small Stock & Domestic or General Security entitlements, opted to keep all of their entitlement and remain part of the Scheme. Of the remaining Members:

- 5 Members opted to provide some of their General Security entitlement and remain part of the Scheme,
- 5 Members opted to provide all of their General Security entitlement and remain part of the Scheme,
- 2 Members opted to provide all of their General Security entitlement and exit the Scheme, and
- Five Members with small General Security entitlements (30 ML) opted to provide all of their entitlements and exit the Scheme.

A total of 12,504 ML was transferred to the Australian Government with an additional 1,390 ML transferred to the Scheme Loss WAL.

6.11.5 Budget

The Australian Government paid $16,994,850 for the acquisition of 8,852 ML of water entitlements as part of the rationalisation process of the Tenandra Scheme Modernisation Project. Each Member was paid 61% of their gross payment entitlement in late 2010, with the balance in April 2011. These payments were in line with the Milestone payments received from the Commonwealth, but in conflict with normal water trading transactions when full payment is expected at settlement and transfer of the water.

7.0 Key performance indicators

7.1 Overview

The Tenandra Scheme Modernisation Project has achieved all of the Key Performance Indicators described in the Private Irrigation Infrastructure Operators Program (PIIOP) (Table 36).

Table 36: Summary of key outcomes of the Tenandra Scheme Modernisation Project.

Key performance indicator	Outcome
Program delivers the contracted share of the water savings in the form of water entitlements transferred to the Australian Government	The Tenandra Scheme Modernisation Project has delivered 12,504 ML of water savings in the form of water entitlements to the Australian Government.
Reductions in water losses to farm gate and improvements in network water use efficiency, water management and monitoring	The Tenandra Scheme Modernisation Project has significantly improved water delivery efficiency from a long-term average of 80% to 93%.
Reductions in on-farm water losses and improvement in on-farm water efficiency and water management	Three on-farm efficiency projects undertaken as part of the Tenandra Scheme Modernisation Project have achieved total water savings of 859 ML, with 486 ML of these savings returned to the Australian Government as water entitlements.
Increases in the volume of available water from water savings and improved flexibility and control of water for irrigated crop production, livestock consumption and domestic consumption for customers /members of private irrigator infrastructure operators	The Tenandra Scheme Modernisation Project has increased the volumes of available water for its remaining members via improved water delivery efficiency, on-farm efficiency projects, improved network management and rationalisation.
Reduction in the risks of water availability that result in water being available more frequently or in larger volumes for irrigation production that leads to additional opportunities for economic revenue for customers/members of private irrigation infrastructure operators, which assists in securing a sustainable future for associated irrigation communities.	The Tenandra Scheme Modernisation Project has reduced the risks associated with water availability, created opportunities for additional crop production and economic revenue, thereby improving the profitability and sustainability of its members and assisting with securing a sustainable future for associated irrigation communities.

7.2 Estimating the impact of PIIOP

The long-term outcomes from the modernisation of the Tenandra Scheme are not yet known as the construction work to modernise the Scheme has just been completed. The real outcomes of modernisation will occur as the revised scheme operates over the next several years.

The information presented in this Final Report of the outcomes achieved by the PIIOP project has been estimated or modelled. The post-project outcomes are based on estimates of what the project could have achieved if the project was finished 14 years ago. These estimates do not predict the future but rather present an understanding of the impact of the modernisation works on crops and revenue.

7.2.1 Water efficiency measures and productivity

The primary economic impact of PIIOP-funded infrastructure projects revolves around changed opportunities for crop production and revenue for ongoing members, and reduction of debt by the sale of rationalised water.

The basic rationale of PIIOP is that the infrastructure works lead to improvements in water availability for irrigators (in terms of capacity to manage water and/or increased volume). The main outcome of the water efficiency measures funded by PIIOP is to generate water savings by reducing the loss of water from irrigation networks and farms through seepage, evaporation and escapes. Estimates of the potential results of water savings rest on the extent to which additional water (compared to pre-project) is retained by the irrigation network and its farmers and the extent to which changes in control over water and flexibility of delivery affect crop production.

Water efficiency measures, such as those installed and conducted by the Tenandra Scheme, create water savings and maintain or increase water availability at the crop root zone even when there is a reduction in the water entitlements owned by Tenandra farmers. A key element of sustainability for irrigation schemes is the capacity to deliver a higher proportion of water to the farm gate measured against the volume of water extracted from the river offtake. Improved delivery efficiency could mean that the volume extracted from the river offtake could be reduced without necessarily reducing the volume delivered to the farm gate or to crop root zone.

In addition, improved water delivery efficiencies in the network mean that a lower volume of water at the river offtake is needed before pumping can commence. This can result in additional years of irrigated crop production to what was possible prior to the network upgrades. Also, on-farm investment can result in a reduction in water losses from seepage if the on-farm water distribution network is improved. Upgrading water delivery infrastructure for crops (such as replacing flood irrigation with lateral sprinkler systems) would allow for less water being lost below the crop root zone and applying the right volume of water at the right times.

Improvements to water availability enable increased crop production (in terms of more area under crop due to higher water volumes and/or improved yields through better

water management) and more crops and/or better quality crops can lead to higher revenue for irrigators. If productivity is a measure of output per unit of input, then PIIOP changes productivity by achieving similar outputs at crop level (which depend on the application of water to the crop root zone) using less units of irrigation water measured at the river offtake. This is because the infrastructure works, both off and on-farm, improve the capacity to deliver water more effectively to the crop root zone by minimising water losses to seepage and evaporation.

Improved water efficiency therefore reduces business risk levels for farmers and delivers an improved ability to plan and manage production under variable water allocations. So there are important potential outcomes for farmers, but this Final Report also discusses the towns and rural areas around the irrigation network because part of the PIIOP objectives relate to outcomes for irrigation communities.

7.2.2 Links to irrigation communities

Irrigation communities are the townships and rural areas within the boundary of the local government area(s) in which the private irrigation infrastructure operators are located.

The modelled outcomes from the Tenandra PIIOP project are based on a particular understanding of the linkages between ‘irrigator communities’, a ‘sustainable future’ and PIIOP.

There is a link to a sustainable future for irrigation communities through PIIOP infrastructure projects because improving the efficiency of on and off-farm water management creates the potential for increased crop production and this means there is a potential for increased discretionary income which could mean increased farm profitability or spending or reduced debt. Increased crop production post project would generate improved farm revenues. Greater water efficiency would enable irrigators to better withstand the impacts of reduced water availability in the future compared to pre-project conditions. If post-project, irrigators are able to deliver similar or improved crop outcomes with less water entitlements, or are more profitable with less water entitlements, then those irrigators are more economically sustainable than they were pre-project.

To the extent that increased discretionary income converts into improved capacity for discretionary spending by irrigators in local communities for goods and services, this helps sustain irrigation communities by helping local businesses and services (post offices, banks etc) to be more viable. In turn, this helps support secondary employment (retail etc), and leads to more people being able to reside long term in townships because of a more secure economic base, leading to more services being available (teachers etc). There may also be multiplier effects of such increased spending that could translate into improved employment opportunities in local businesses. The multiplier effect is the boost to local economy that results from locally-owned independent businesses, owners, and employees spending business revenue within the region.

The actual income for irrigators in the future will depend on the extent to which the opportunity is taken up, which is dependent on available water, seasonal conditions, market conditions, and business decisions. Individual financial circumstances particularly debt levels will change the extent to which increased revenue is used for discretionary expenditure or debt reduction. The actual outcomes for irrigator communities in the future will depend on a large number of factors shaping regional trends and influences that include the Basin Plan outcomes such as this infrastructure investment.

This Final Report does not describe these other factors or predict what the outcomes will be in the future. What it does present is the outcomes of modelling of the changed opportunity for customers of private irrigation infrastructure operators for increased productivity and revenue created through the PIIOP program. It presents the difference created by PIIOP by comparing pre-project and post-project crop and revenue outcomes.

7.2.3 Key assumptions

To estimate the impact of PIIOP on the Tenandra Scheme, a detailed 'whole of scheme' economic model was created by the Department of Agriculture and Water Resources in Microsoft Excel to describe the changes in water availability and the cumulative financial performance of remaining and exiting Scheme members pre and post-project. The two key assumptions in the model are a lengthy period to better understand water availability and efficiency and an emphasis on the cumulative interaction of cost, revenue and debt over a lengthy period to better understand the difference created by the opportunity for increased crop production.

The post-project modelling is based on estimates of the impact PIIOP would have had on the Tenandra Scheme if the construction work was finished 14 years ago. A 14 year period was chosen for the model because water efficiencies and crop production scenarios vary in dry, medium and wet years and good quality data existed for that period. There is no 'average' year that could accurately reflect the actual performance of the scheme in varying conditions. A fourteen year period reflects a diversity of climatic conditions and allocation decisions, with periods of relatively high water availability through to four years of no irrigated crop production. This provided a solid basis to test the future performance of the Scheme in the same range of climatic conditions.

The first step to understanding the Tenandra project outcomes was to model the pre-project relationship between crop production and the quantity of water available over the 14-year period 1999–2013.

The second step was to assume that the modernisation works were completed 14 years ago and change the volume of water entitlements to account for transfers to the Commonwealth and apply post-project water delivery efficiency outcomes. Consideration was also given to changed business practices by irrigators to take advantage of the modernisation outcomes. Restricting the changes to these limited variables allows for no change to market prices, weather patterns, or allocation announcements in the pre and post-project modelling.

The third step was to compare pre-and post-project outcomes to estimate the difference that can be attributed to the modernisation works funded by PIIOP.

The advantages of using a static past and changing only the water availability and efficiency variables is that it is possible to isolate the impact of PIIOP without a complex way of accounting for the impact of future business decisions, rainfall patterns, crop prices, input costs, and so on. As market prices, for instance, are the same both pre-project and post-project in the modelling, market prices are not a variable that provides any influence on the difference between pre-project and post-project outcomes. Farmers are responding in both scenarios to exactly the same set of market conditions.

The estimates generated by the model of project outcomes in this final report have been informed by the best data available at the time of completion of the project, as well as collaboration between members of the Tenandra Board, its consultants and Departmental officials to fill data gaps and add a decision-making perspective to inform crop production and business strategies. For instance, the pre-project economic model had 14 years of data for actual water availability, rainfall and Scheme performance, along with published data on the costs of production, input from Scheme members and industry advisors to ensure the modelled data reflected the experience of those involved in the Scheme, and actual prices for water, crop inputs and crop outputs. The post-project water delivery efficiency numbers have been derived from pondage testing and operation of the Scheme in 2012-13 to inform post-project efficiency, noting that this is not the same as 5 to 10 years of data on the actual operation of the scheme.

The disadvantage of estimation is that the results will remain an estimate of possible future performance, and are subject to all the limitations of estimation. Therefore it is important to note that the following outcomes are not forecasts of post-project performance, but rather are estimates of the potential opportunities created through the infrastructure upgrades funded by PIIOP.

These potential opportunities are measured in terms of crop production translated to pre-tax revenue outcomes for both farmers and for the scheme as a whole. The focus on gross revenue outcomes is important in the context of debt in the agricultural sector which has probably helped to shape the willingness of farmers to participate in water purchases and infrastructure upgrades through the Murray-Darling Basin Plan. According to the Reserve Bank, total Australian farm debt has risen exponentially since 1965 and increased above the exponential trend line with a rise on average of 22% annually between 2004 and 2008 before total debt levelled off (Hutchings 2013). The investments by the Australian Government in the Murray-Darling Basin area have the potential to assist farmers to cope in this context of rising debt and falling equity which occurred in the recent period of drought.

The revenue outcomes have been estimated for both pre and post project scenarios by tracking the cumulative cash flow of farm businesses taking into account whole of farm costs and revenues in the context of debt. The cumulative cash flow outcomes across several years provides a clearer picture of possible financial outcomes for farmers than an annual profit/loss statement which lacks the context of debt which changes year by year (Hutchings 2013).

Finally, it is important to note that a different methodology would be required if there is an attempt to measure the actual outcomes of the modernisation works in ten years' time when actual scheme performance data would be available because the changes to available water, seasonal conditions, market prices, and business decisions would need to be accounted for in any discussion of the impact of PIIOP. In addition, the entire range of external factors that determine actual social and economic outcomes for irrigators and irrigation communities would need to be investigated and accounted for before any claims about PIIOP outcomes could be made.

7.2.4 Modelling farms

The model is based on a 'model farm' – a hypothetical picture of a representative farm's water use, costs and revenues, based on benchmarking data and the experience of people involved in the scheme. The farms do not present the costs and revenues or crop production of any actual farms.

There were two broad types of farm in the pre-project Tenandra Scheme that were selected for modelling - large farms with irrigators who crop as much as possible each year, and have different farming and business strategies compared to the small farms who are occasional irrigators. Small farms tend to crop when there is sufficient water available, but realise the value of their water assets on the temporary water market when there is insufficient water available to crop.

Post project, the large farms were split into two groups – those who received PIIOP funding for on-farm works and those that did not. There were no small farms that received PIIOP funding for on-farm works. A separate post-project model farm was developed for scheme members that opted for rationalisation, to understand the financial impact of ceasing irrigation.

The six types of 'model' farms within the Scheme were:

- Pre-Project - large farms with more than 400 ha of irrigated area
- Pre-Project - small farms with less than 400 ha of irrigated area
- Post Project - large farms with more than 400 ha of irrigated area with no on-farm efficiency projects
- Post Project - large farms with more than 400 ha of irrigated area that undertook on-farm efficiency projects
- Post-Project - small farms with less than 400 ha of irrigated area
- Post-Project - rationalised farms that no longer had irrigation (former small farms).

A model farm process was chosen to avoid presenting the actual economic performance of real farms. While the small numbers of farms involved in the Tenandra scheme makes it relatively easy for those with local knowledge to guess which farm falls into each category, it is important to note that none of the outcomes actually reflect real farm performance. Each actual farm will have differing results based on their level of debt, the scale of their production and their business decisions.

The model results do not translate directly to profit outcomes, as the impacts of tax, additional debt repayments, capital investments, additional borrowings, and additional living expenses over the base case would all affect actual farm profit outcomes. Any farmer wishing to apply these outcomes to their own properties will need to make allowances for these factors and the dimensions and performance of their own property, and cannot assume that the modelled outcomes are directly representative of their own circumstances.

Each model farm included a range of irrigation, dryland cropping and grazing enterprises typical of the landholders on the Scheme. All of the model farms pre-project had a primary irrigated crop of cotton. Wheat was chosen as a crop representative of the costs and revenues typical of dryland cropping across several crop types.

To reduce the complexity of the economic model, several farms that did not fit the primary farming model of cotton / wheat / dryland were excluded. The excluded farms tended to have very small amounts of water entitlements used for stock and domestic purposes and were not major crop producers either pre or post project. One farm retained significant amounts of water entitlements post-project but their business model now focuses on high value livestock.

Whole of scheme outcomes were developed by scaling the dimensions of the model farms to the dimensions of the scheme. For instance, as the large model farm dimensions were set by dividing the total dimensions of all the large farms in the scheme; whole of scheme outcomes could then be generated by multiplying the results of the large model farm back up to the dimensions of the large farms.

7.3 Water savings

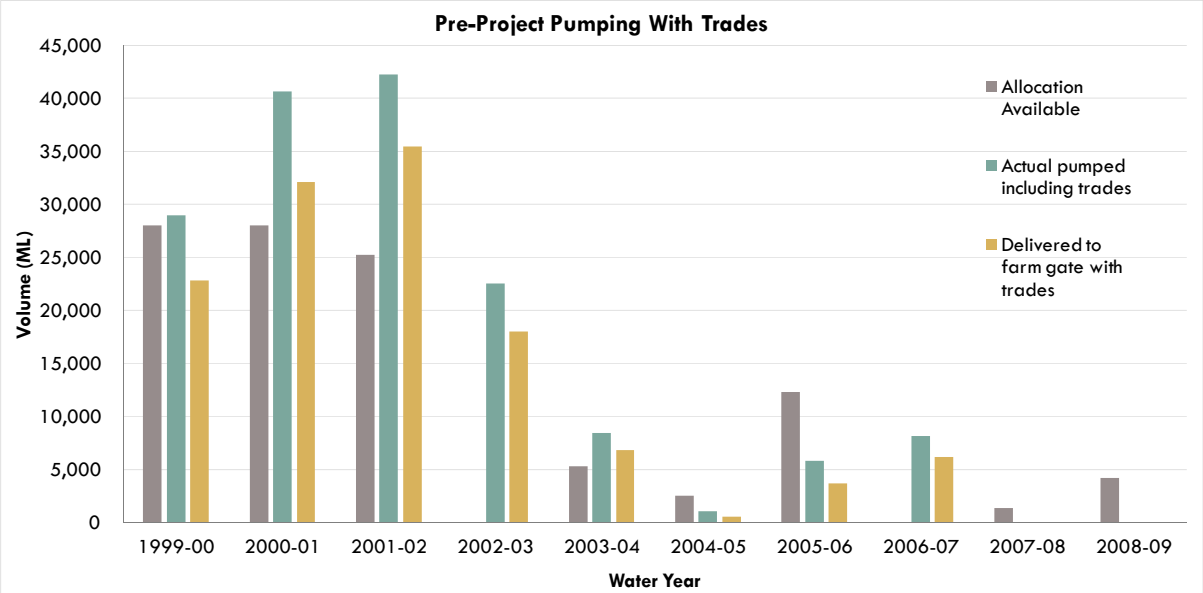
The Tenandra Scheme Modernisation Project has delivered 12,504 ML of water savings to the Australian Government. These savings were achieved via:

- increased efficiency of the Scheme, contributing 2,514 ML of savings;
- increased on-farm efficiency of individual members, contributing 486 ML of savings;
- rationalisation of water entitlements on the Scheme, contributing 9,504 ML of savings.

7.3.1 Pre PIIOP pumping and performance

Most years prior to modernisation the scheme pumped more water than the yearly Tenandra Scheme available allocation (Figure 42). This is because the members transferred water from other sources outside of the Scheme allocation onto the Scheme on a temporary basis and were allowed to carry-over water from season to season.

Figure 42: Allocation available, actual pumping and volumes delivered for the Tenandra Scheme for the 10 years leading up to modernisation, figures include temporary trades of water.



7.3.2 Post PIIOP pumping and performance

To measure the impact of PIIOP against Scheme entitlements and against Scheme performance including external sources of water, the performance of the Scheme Post PIIOP was modelled against 2 scenarios. Firstly using the remaining Scheme entitlement annual allocation only; and, secondly using total Scheme pumping including temporary trades and allowing for carry-over of allocation water or traded water from year to year.

When the water traded on a temporary basis was removed from the modelling, the modelling indicated that:

- The volume of Scheme General Security water allocation available to be pumped by the Scheme each year was modelled to decline by 45% in line with reduction in entitlements.

- The volume of Scheme General Security water allocation delivered by the Scheme was likely to decline by about one third and by up to 8,000 ML during high allocation years (Figure 43, Figure 44).

- A small volume was modelled to be delivered in 4 years Post-Project where water was not modelled to be delivered Pre-Project (Figure 43).

Figure 43: Modelled allocation volume available to be pumped during the 14-year modelling period (1999–2013) excluding temporary trades and carry-over.

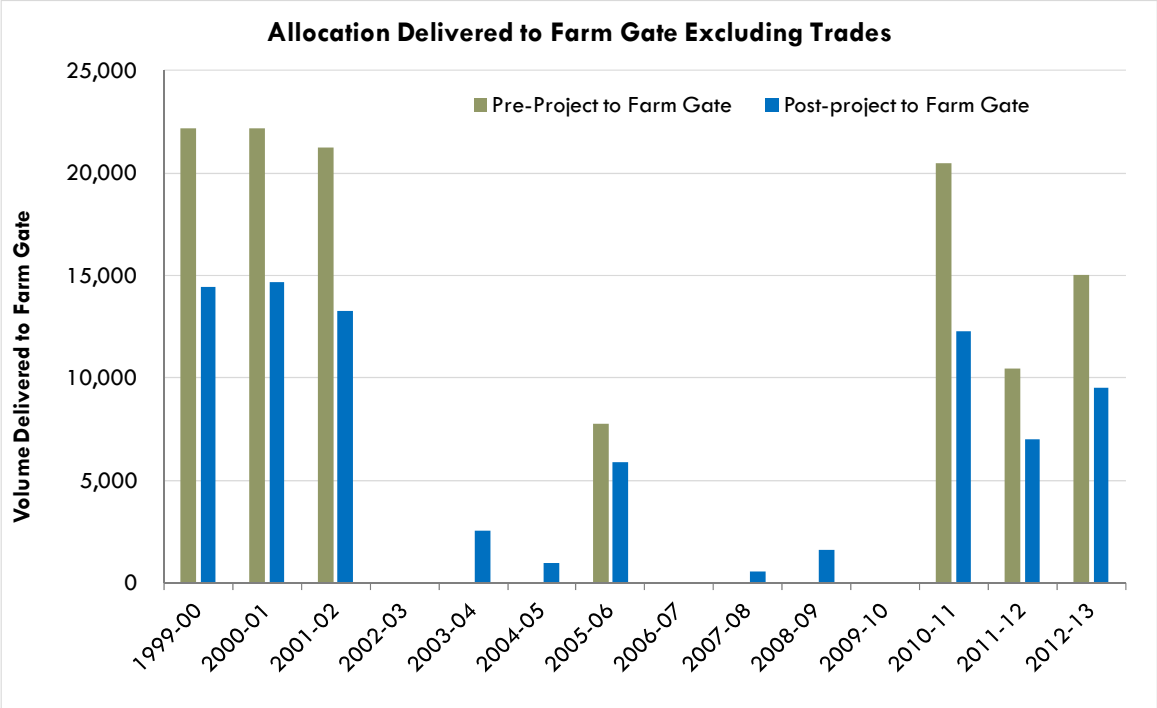
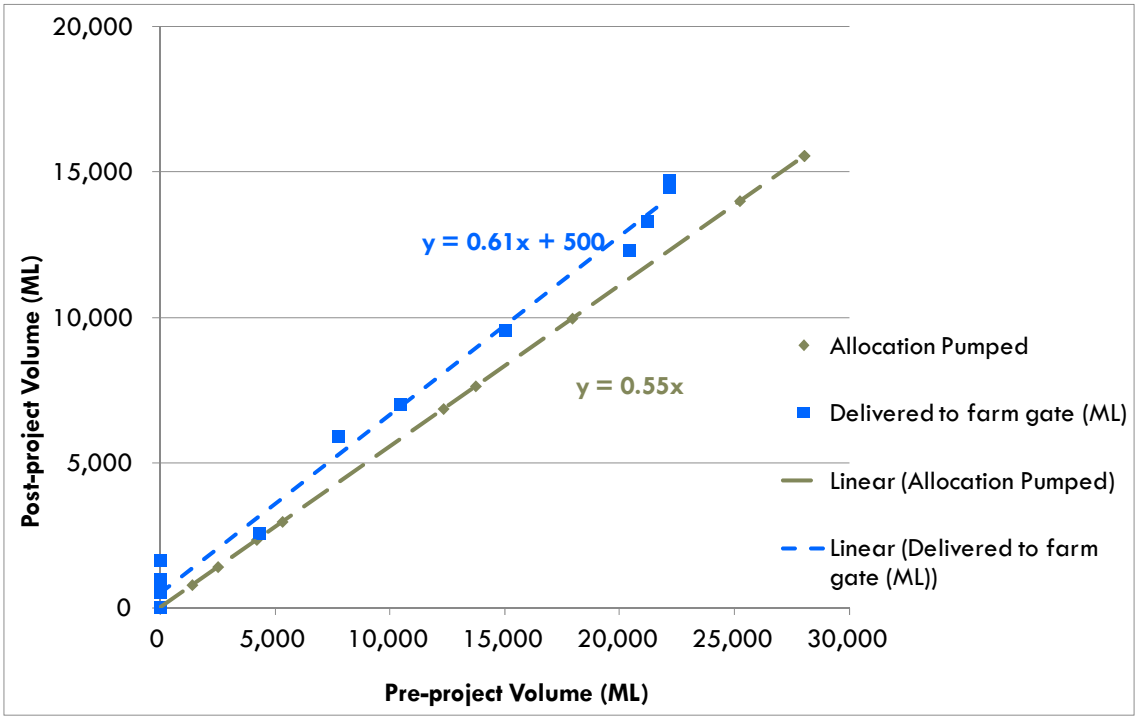


Figure 44: The volume of Tenandra Scheme Entitlements pumped by the modernised Tenandra Scheme will decline by about 45%, however farm gate deliveries of Scheme entitlements will decline about one third from pre-modernisation volumes.



7.3.3 Total Pumping

The historical practice of Tenandra Scheme members purchasing and trading water on the temporary basis and carrying over water from season to season is likely to continue as farmers take advantage of the increased efficiency of the Tenandra Scheme Post PIIOP. Farmers may well be more inclined to use water they currently apply to other farms outside the Tenandra Scheme and are more likely to compete in the market for temporary water given the higher financial returns they are able obtain after modernisation of the Tenandra Scheme.

When trading volumes were included in the model, modelling indicated that:

- The total volume of water pumped by the Scheme each year was modelled to decline by about 25% from pre-modernisation levels, despite a 45% reduction in the Scheme's General Security water entitlement (Figure 42, Figure 46). The reduction in modelled pumping was lower than the reduction in water entitlements because the modelling includes expected changes to decision making as farmers take advantage of the increased efficiency of the Tenandra Scheme.

- The total volume of water pumped by the Scheme is likely to decline by up to 13,000 ML during high allocation years (Figure 45).

- There is likely to be little change in the total volume of water pumped by the Scheme during low allocation years, reflecting the willingness of the remaining Scheme members to transfer water entitlements to a more efficient water delivery network and the exit of less active irrigators from the Scheme.

- A small volume was modelled to be delivered Post-Project in 4 years where water was not modelled to be delivered Pre-Project.

Figure 45: Modelled total volume pumped during the 14-year modelling period (1999–2013) including temporary trades and carry-over water.

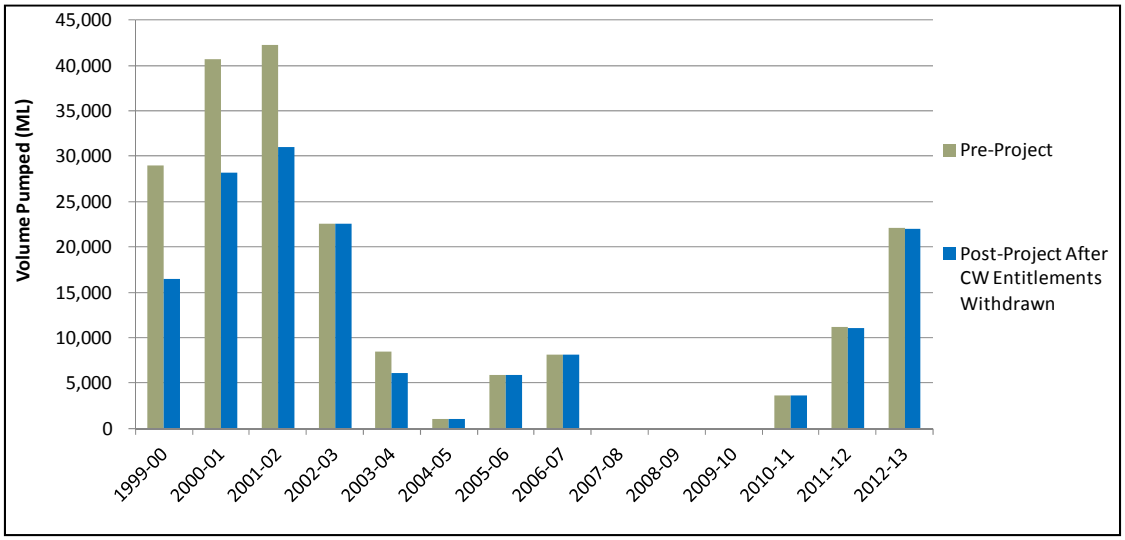
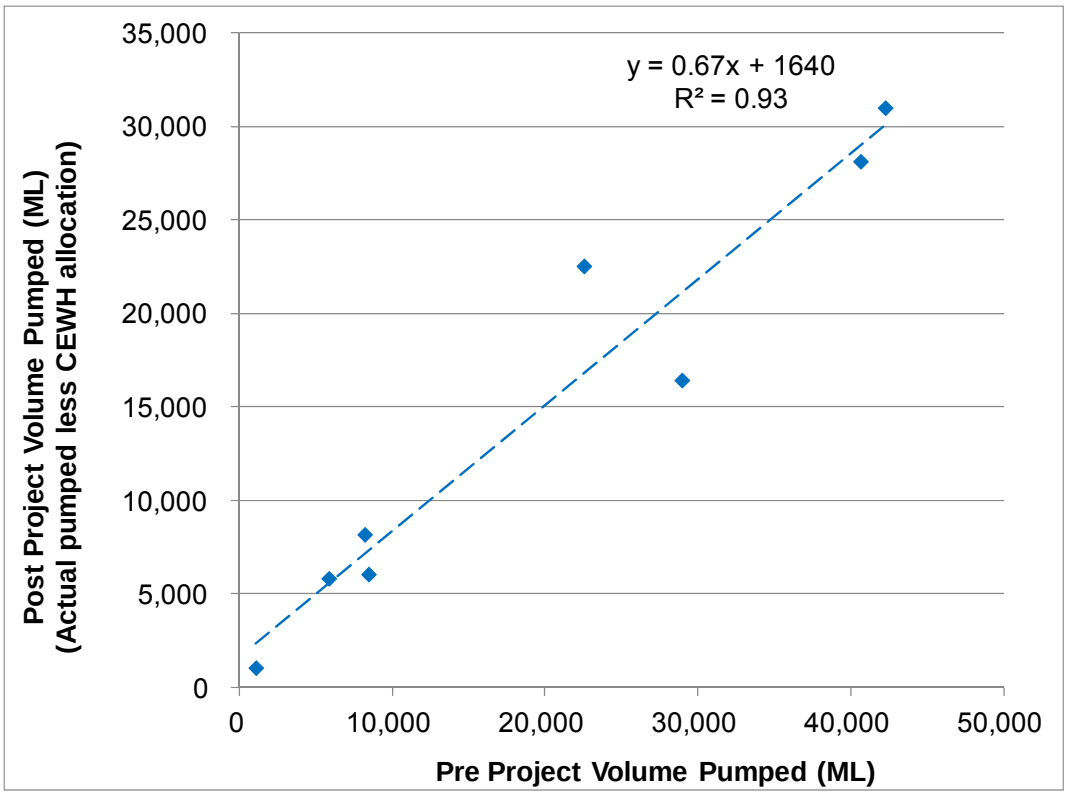


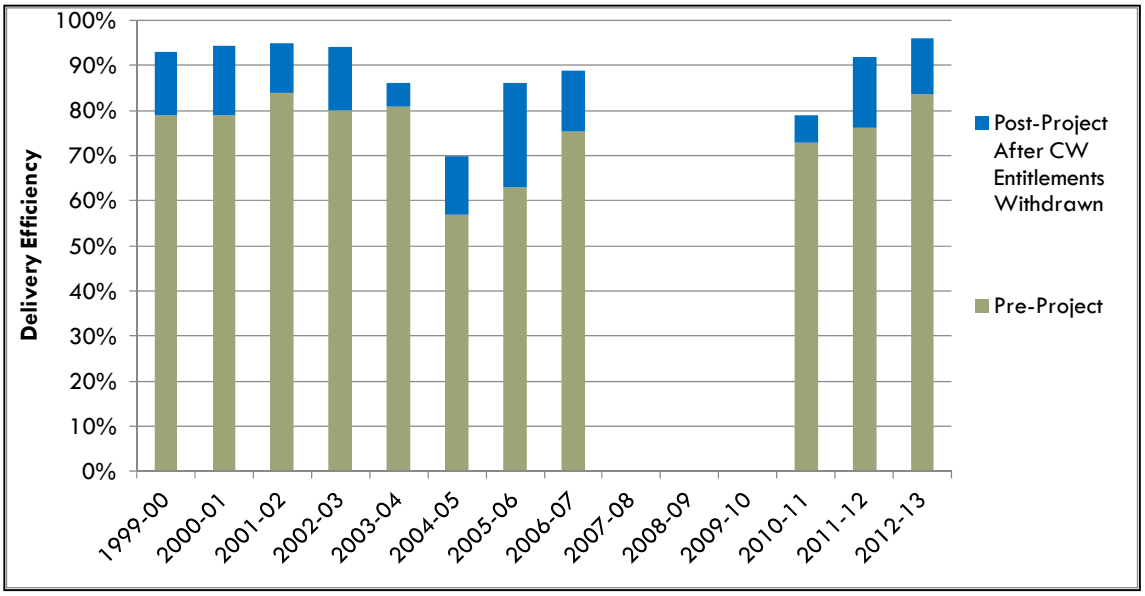
Figure 46: The total volume pumped including trades was modelled to decline by about 25%.



7.4 Improved delivery efficiency

The Tenandra Scheme Modernisation Project has significantly improved water delivery efficiency from a long-term average of 80% to 93% (Figure 47). This improved efficiency is a result of significant changes to the channel design, infrastructure and controls.

Figure 47: Estimated impact of improved delivery efficiency of modernised Tenandra Scheme during the 14-year modelling period (1999–2013).

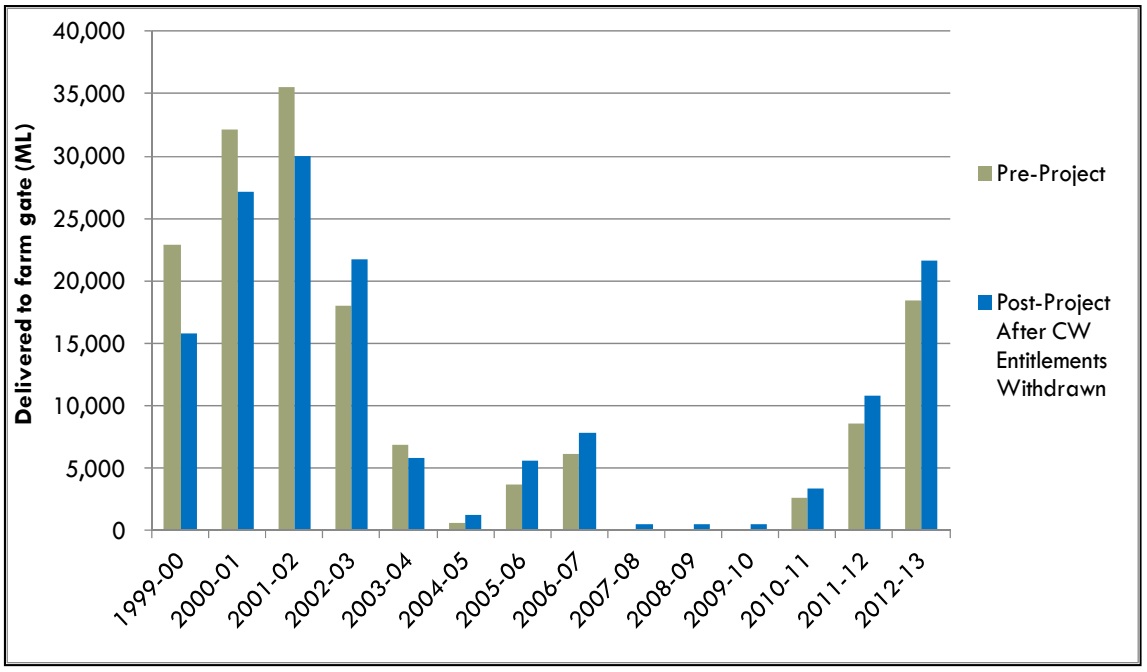


The modelling indicated that improved water delivery efficiency and network management should lead to:

- a reduction in total farm gate deliveries of about 6,000 ML in high allocation years (Figure 48), even though the total volume pumped will be reduced by up to 13,000 ML (Figure 45).

- An increase in total farm gate water by about 20% in low allocation years due to increased incentive to grow irrigated crops.

Figure 48: Estimated total farm gate delivery of modernised Tenandra Scheme during the 14-year modelling period (1999–2013) after Commonwealth entitlements are withdrawn.



7.4.1 Impact of increased delivery efficiency on each farmer.

In line with the increased improved efficiency of the Scheme it was modelled that the average amount of Scheme General Security water allocation (excluding trades) delivered to each farmer on the scheme post PIIOP will increase by about 15 % (Figure 49, Figure 50). This is due to the improved delivery efficiency and the reduced number of growers. This increase was further enhanced and leveraged when the temporary water was included.

Figure 49: The average amount of Scheme General Security allocation water delivered to each farmer on the scheme post PIIOP was modelled to be greater post PIIOP than pre PIIOP.

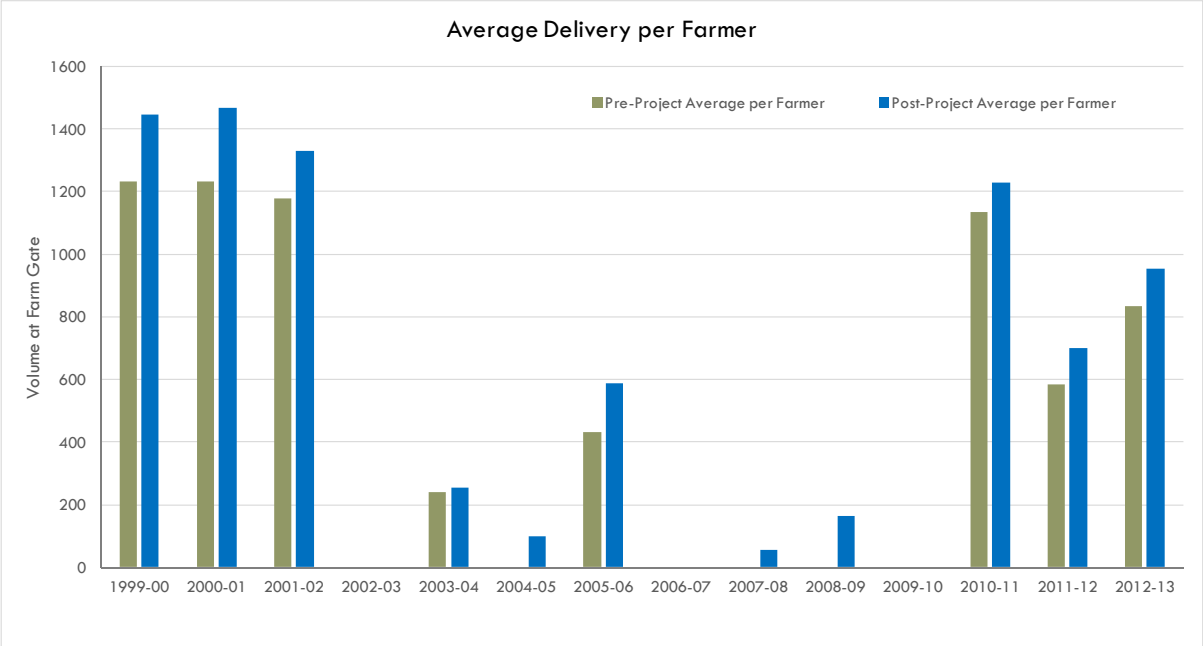
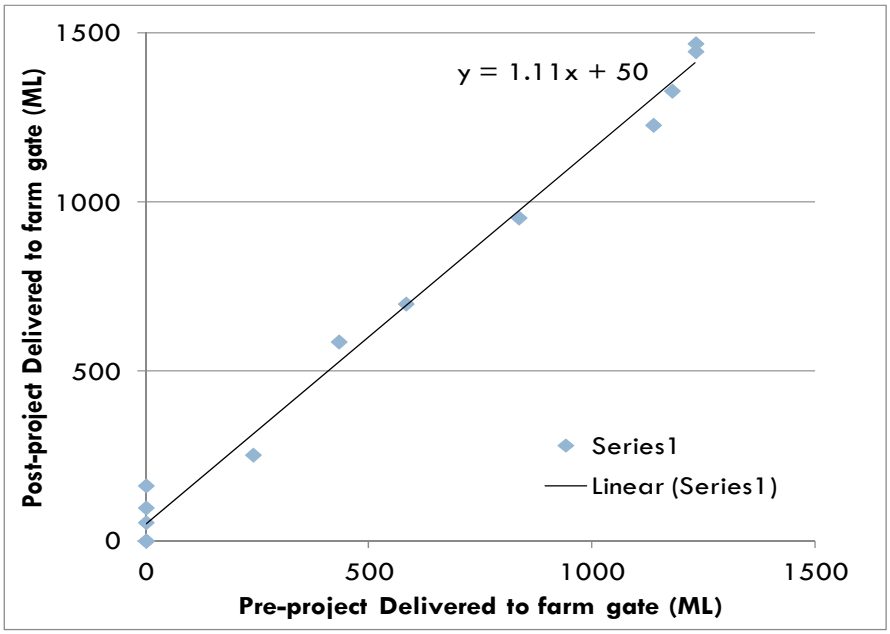


Figure 50: The average amount of Scheme General Security allocation water delivered to each farmer on the scheme post PIIOP will increase by about 15 %.



7.5 Impact of PIIOP project on Scheme operation and management.

The Modernisation Project will significantly reduce the operational costs of the Scheme. It is estimated the installation of automated and remote control and monitoring systems for the pumps, regulators and offtakes will halve the workload of the Channel Manager during peak times without affecting water delivery.

Likewise, the automated system will provide real-time data on actual water flow and delivery rates to assist in channel and farm management, better decision-making and faster responses to channel blockages or leaks. It is estimated the use of more efficient pumps will significantly reduce electricity costs. However, total operating and maintenance costs, expressed on per ML basis, are likely to remain or increase slightly owing to fewer members remaining in the Scheme.

7.6 Improved on-farm efficiency

Three on-farm efficiency projects undertaken as part of the Tenandra Scheme Modernisation Project have achieved total water savings of 859 ML, with 486 ML of these savings returned to the Australian Government as water entitlements.

Modelling indicated that:

- The ‘Milawa’ on-farm efficiency project will achieve water savings of 408 ML.
- The ‘Bellevue’ on-farm efficiency project will achieve water savings of 311 ML.
- The ‘Old Bundemar’ on-farm efficiency project achieved water savings of 140 ML.

Additionally, all farms connected to the new channel will be able to receive water at a faster daily delivery rate and increased reliability of supply due to modernised and automated channel control. This will allow members to reduce storage and delivery losses on farm as less water will need to be stored on farm.

7.7 Improved water availability

The Tenandra Scheme Modernisation Project has increased the volumes of available water for its remaining members via improved water delivery efficiency, on-farm efficiency projects, improved network management and rationalisation.

Economic modelling indicated that:

- Large farms (>400 ha) will receive an average of 1,049 ML more water each year, sufficient to plant and irrigate an additional 117 ha of cotton each year (Figure 51).
- Large farms (>400 ha) undertaking on-farm efficiency projects will be able to plant and irrigate an additional 167 ha of cotton (i.e. 50 ha more than large farms not undertaking on-farm efficiency projects) (Figure 52).
- Large farms (>400 ha) were able to grow 11 crops in the 14-year modelling period (1999–2013), an addition of one crop after Scheme modernisation (Figure 52).
- Small farms (<400 ha) will receive an average of 87 ML more water each year, sufficient to plant and irrigate an additional 10 ha of cotton each year (Figure 51).
- Small farms (<400 ha) were able to grow seven crops in the 14-year modelling period (1999–2013), an addition of one crop after Scheme modernisation (Figure 53).

Figure 51: Estimated total water entitlements and area planted to cotton following modernisation of Tenandra Scheme.

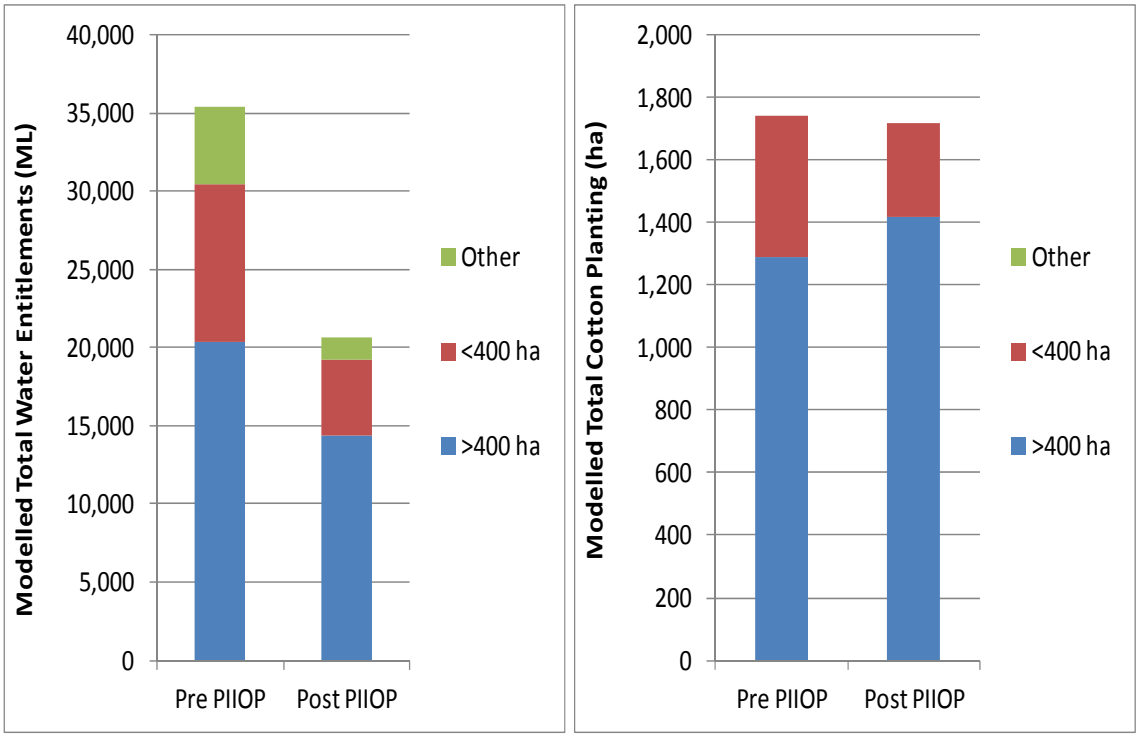


Figure 52: Estimated area planted to cotton on large farms (>400 ha) during the 14-year modelling period (1999–2013).

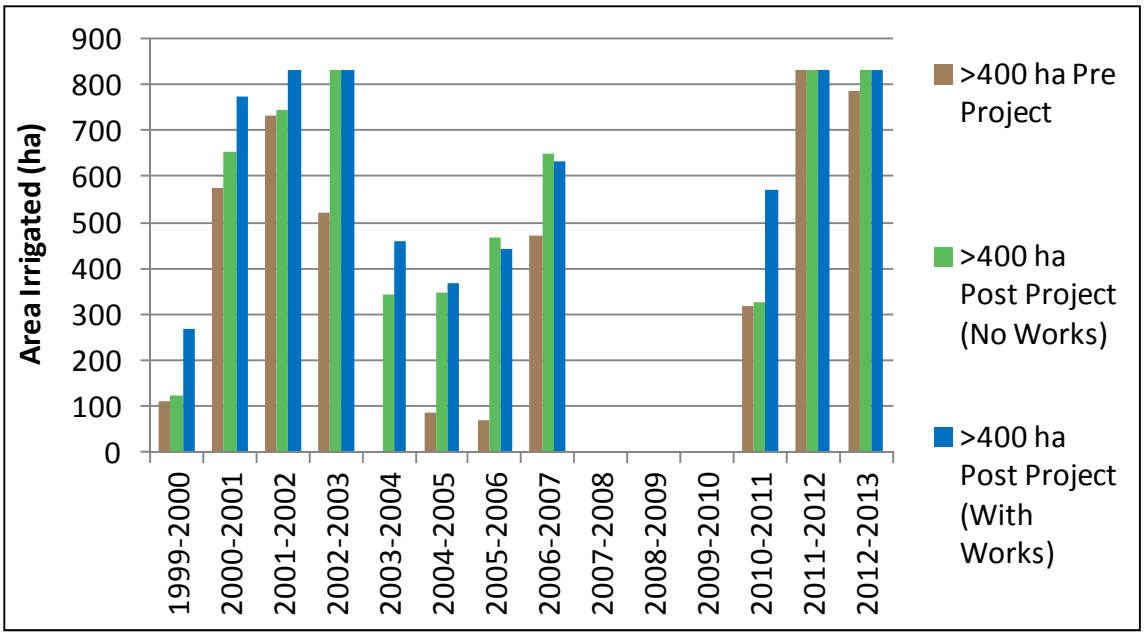
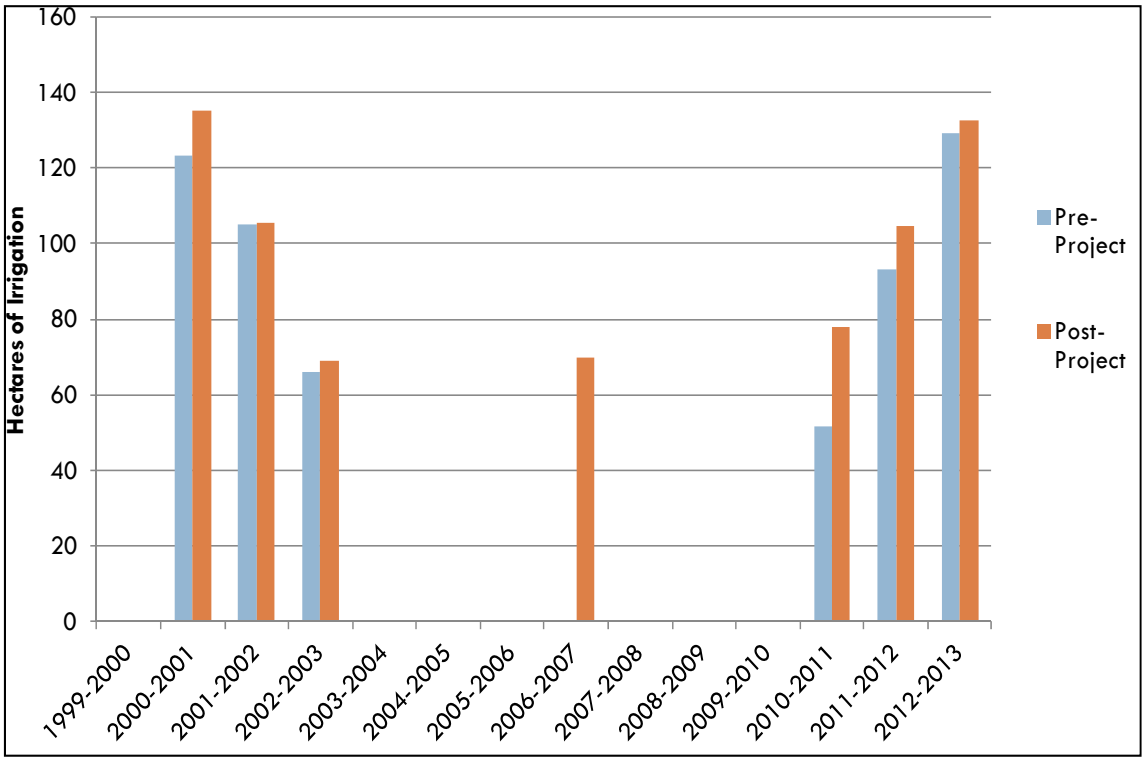


Figure 53: Estimated area planted to cotton on small farms (<400 ha) during the 14-year modelling period (1999–2013).



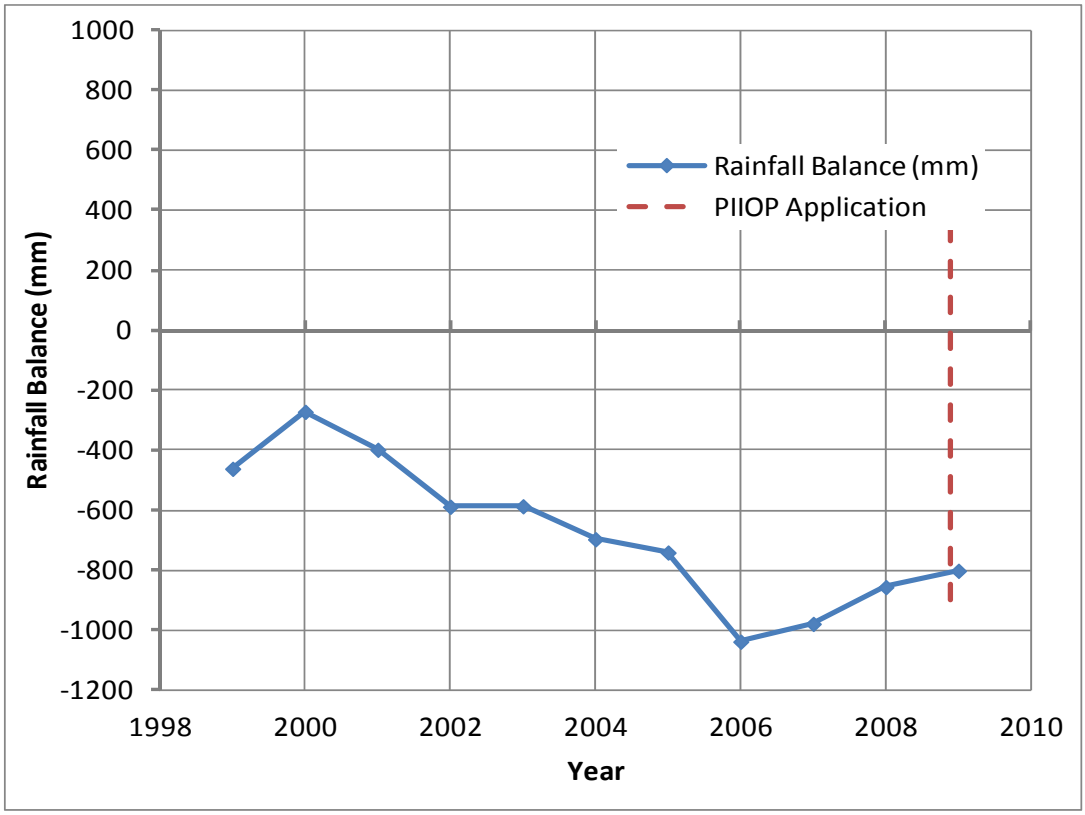
7.8 Improved sustainability of Scheme members

The profitability of cotton production is directly linked to yield, and in turn, water availability. As such, small increases in water availability and delivery efficiency can have a significant beneficial impact on yield and profit. These impacts are even greater on large farms due to economies of scale. The Tenandra Scheme Modernisation Project has reduced the risks associated with water availability, thereby improving the profitability and sustainability of its members.

Between 2001 and 2006, irrigators and farmers in the Warren district received an average of 361 mm/year of rainfall (less than 75% of the long-term average) and very low to zero irrigation allocation. Although rainfall conditions returned close to average in 2007 to 2009 (leading up to the application to the PIIOP program for funding), irrigation water availability remained very low to zero owing to the lack of rainfall in the upper reaches of the Macquarie catchment.

The declining rainfall mass balance (i.e. the cumulative difference between current annual rainfall and long-term average rainfall) throughout the 2000s (Figure 54) had a significant impact on crop yield and farm profit.

Figure 54: Rainfall mass balance in the Warren district, 1999 – 2009.



Economic modelling (Table 37) shows that without modernisation:

- Large farms (>400 ha) recorded an average pre-tax income of approximately $168,000 per year during the 14-year modelling period (1999–2013), while farm equity declined from 72% to 68% (Figures 55 and 57).

- Small farms (<400 ha) recorded an average pre-tax loss of approximately $186,000 per year during the 14-year modelling period (1999–2013), while farm equity declined from 71% to 29% (Figures 56 and 57).

Table 37: Predicted financial performance of all farms during the 14-year modelling period (1999–2013)

Farm type		Average pre-tax income	Farm equity average over 14 years	Average Return on assets managed
Large farms (>400 ha)	Before modernisation	$167,631	Range 72-63% Average 65%	7%
	After modernisation	$585,838	Range 72-113% Average 85%	8%
Large farms (>400 ha) undertaking on-farm efficiency projects>	Before modernisation	$167,631	Range 72-63% Average 65%	7%
	After modernisation	$857,775	Range 72-145% Average 98%	10%
Small farms (<400 ha)	Before modernisation	($185,618)	Range 71-19% Average 40%	2%
	After modernisation	$96,521	Range 71-73% Average 65%	5%
Exiting members	Before modernisation	($185,618)	Range 71-19% Average 40%	2%
	After modernisation	$92,735	Range 82-64% Average 58%	5%

Figure 55: Estimated average annual impact of modernised scheme on income and expenses on large farms (>400 ha) during the 14-year modelling period (1999–2013).

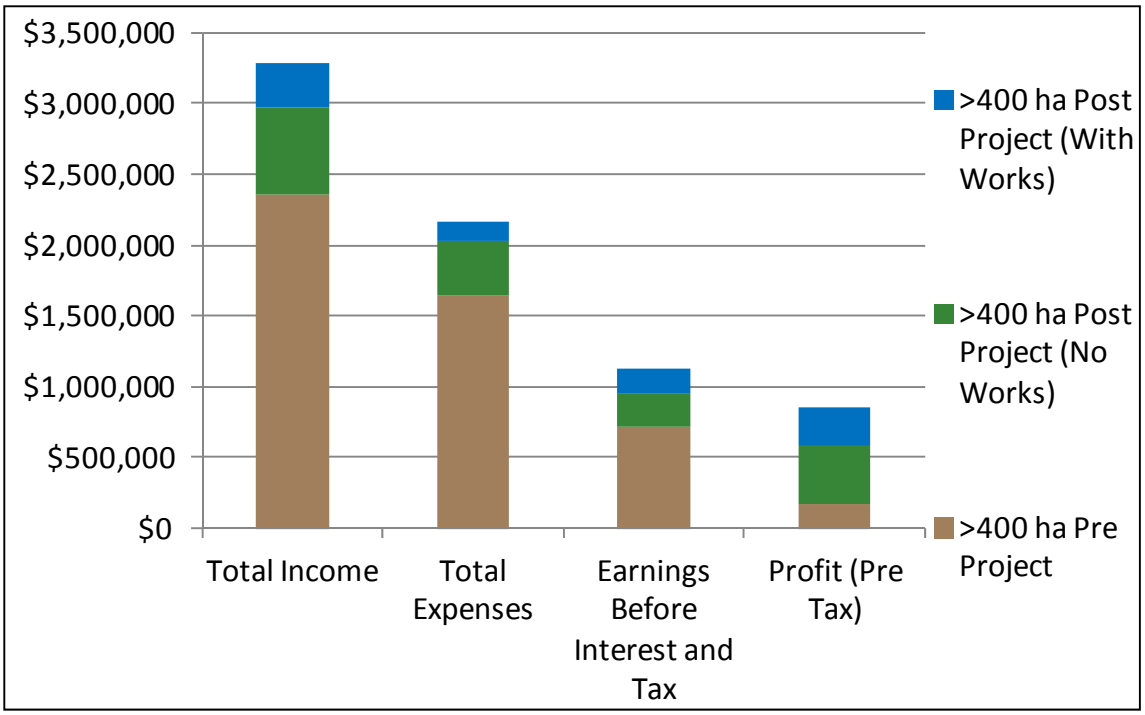


Figure 56: Estimated average annual impact of modernised scheme on income and expenses on small farms (<400 ha).

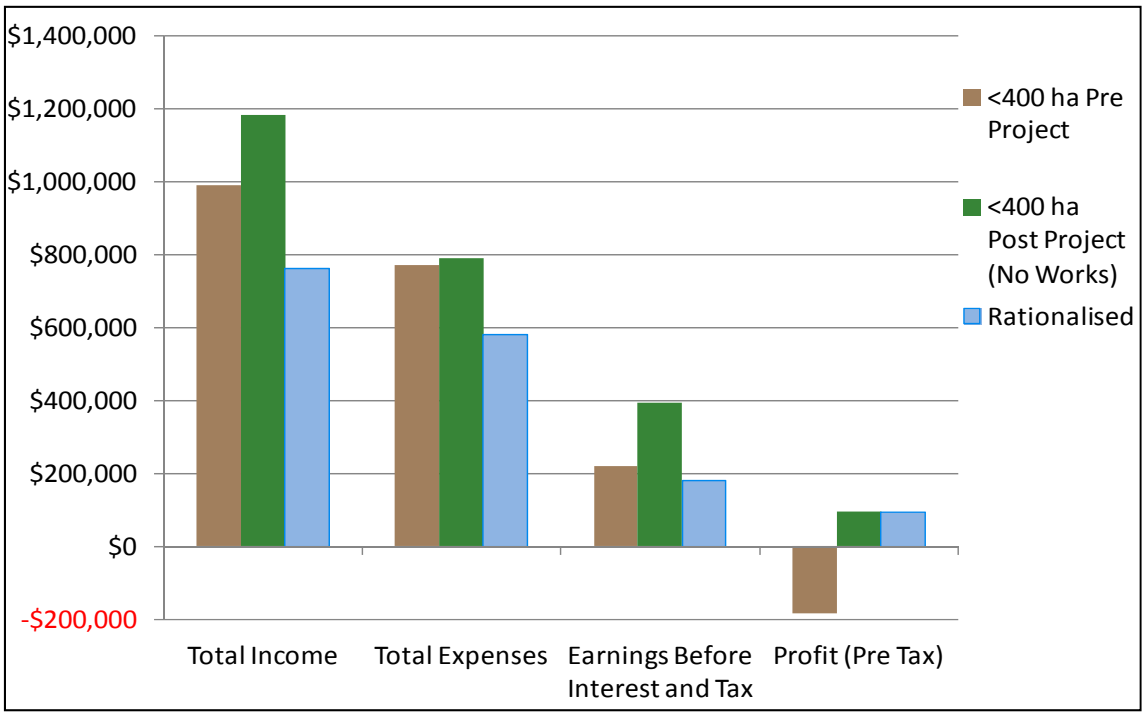
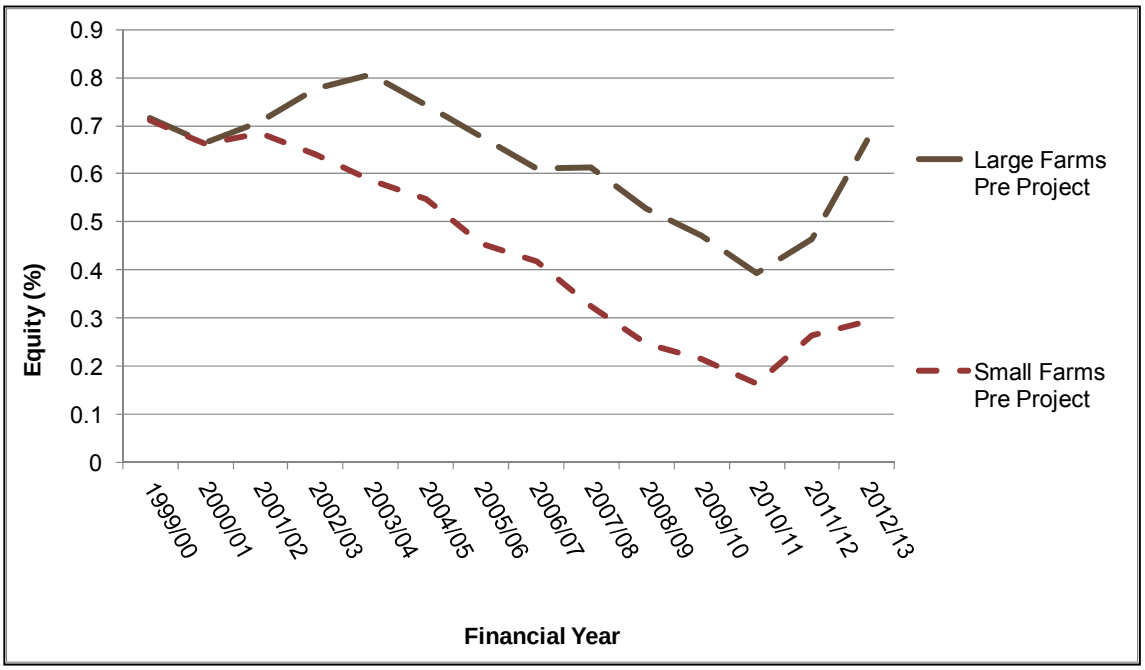


Figure 57: Predicted farm equity without modernisation



Before modernisation, farm equity was modelled to decrease by approximately 30 percentage points (large farms) to 50% (small farms) during and immediately after the 2000 to 2006 drought (Figure 58). This modelled decrease in equity of Scheme members was consistent with the increase in debt described by Hutchings (2013). Economic modelling showed a close relationship between equity (Figure 57) and water balance (Figure 54) but with a lag of up to three years after such a prolonged dry period.

Modelling shows that with modernisation:

- Large farms (>400 ha) recorded an average pre-tax profit of approximately $586,000 per year during the 14-year modelling period (1999–2013), a threefold increase (Figure 55). Farm equity increased from 72% to 112% and average return on assets managed increased by about 1.7% during the same period (Figures 58 & 59).

- Large farms (>400 ha) undertaking on-farm efficiency projects recorded an average pre-tax profit of approximately $858,000 per year during the 14-year modelling period (1999–2013), a fivefold increase (Figure 55). Farm equity increased from 72% to 139% and average return on assets managed increased by about 3.2% during the same period (Figures 58 & 59).

- Small farms (<400 ha) recorded an average pre-tax profit of approximately $97,000 per year during the 14-year modelling period (1999–2013), up from an average loss of $186,000 per year (Figure 56). Farm equity increased from 71% to 76% and average return on assets managed increased by about 2.3% during the same period (Figures 58 & 59).

- Exiting members recorded an average pre-tax profit of approximately $93,300 per year during the 14-year modelling period (1999–2013), up from an average loss of $186,000 per year (Figure 56). Average Return on Assets Managed (ROAM) increased by 2.5% during the same period. Farm equity decreased from 82% to 68%, significantly less than without modernisation (29%) (Figures 58 & 59).

- The total annual average pre-tax income derived from irrigation by members that remain on the scheme after modernisation increased by approximately $3,437,000 per year, a return of $275/ML for the 12,504 ML of water entitlement transferred to the Commonwealth under the PIIOP project. This is more than twice the return of large farms before modernisation, 50% higher than the net irrigation income of large farms without on-farm efficiency projects and 20% higher than large farms with on-farm efficiency projects (Table 38).

Figure 58: Predicted equity of all farms during the 14-year modelling period (1999–2013).

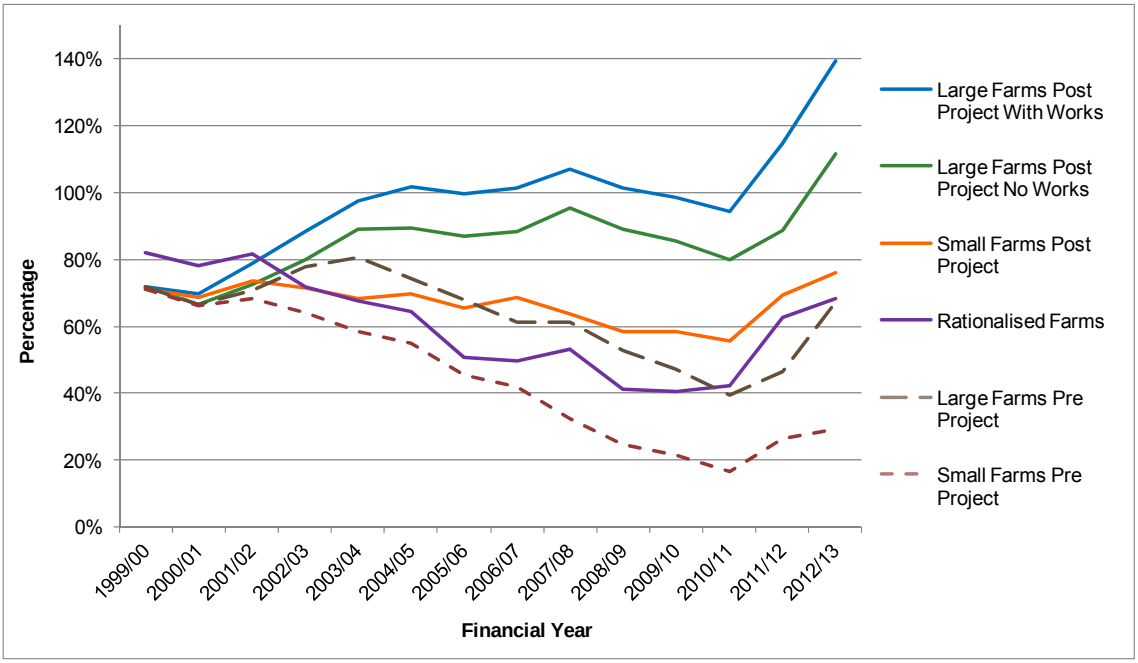


Figure 59: Predicted average return on assets managed during the 14-year modelling period (1999–2013).

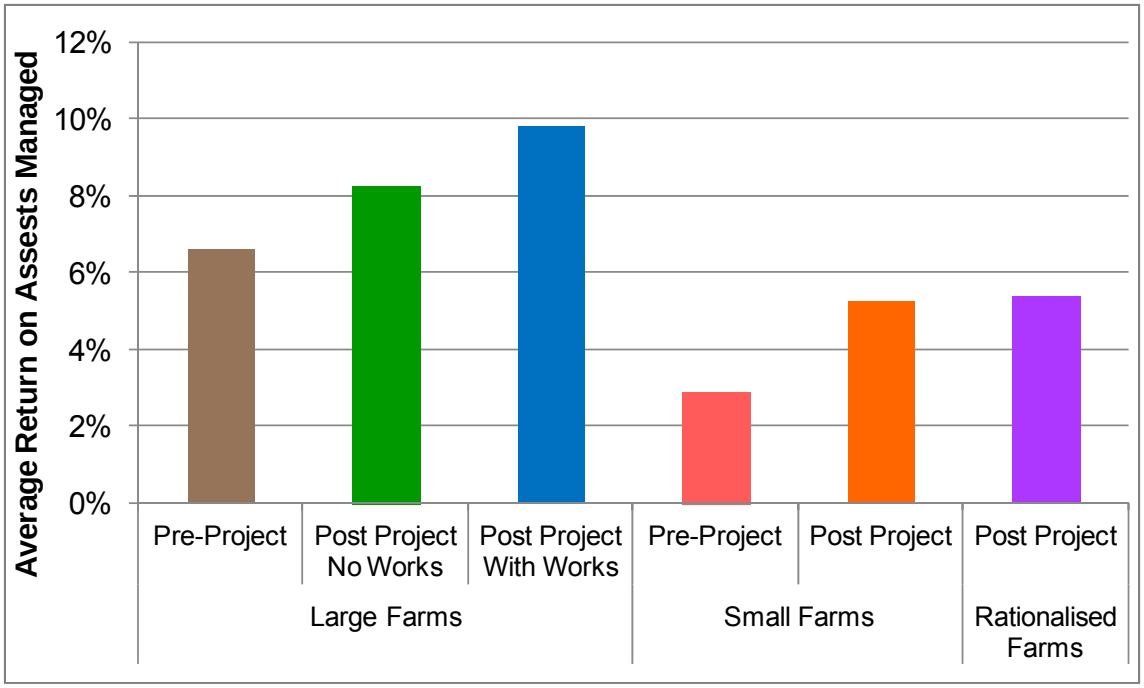


Table 38: Estimated average annual net return per ML during the 14-year modelling period (1999–2013)

	Water entitlement	Net irrigation Income	Net return per ML of entitlement
Large farms (before modernisation)	5087	$602,372	$118
Large farms (after modernisation)	4804	$934,930	$195
Large farms with on-farm efficiency projects (after modernisation)	4804	$1,086,281	$226
Small farms (before modernisation)	1357	-$6,213	-$5
Small farms (after modernisation)	1125	$162,796	$145

The PIIOP project was modelled to maintain overall cash flow at a Scheme level during the extend drought from 2002 to 2006 (Figure 54) until high irrigation allocations and high district rainfall in 2010-11 (Figure 60). This is a major achievement as at a Scheme level, combined cashflow declined dramatically during this period (Figure 60) as did the equity of members (Figure 58).

Figure 60. The PIIOP project was modelled to assist members maintain Scheme level overall cash flow until high allocations returned in 2010-11.

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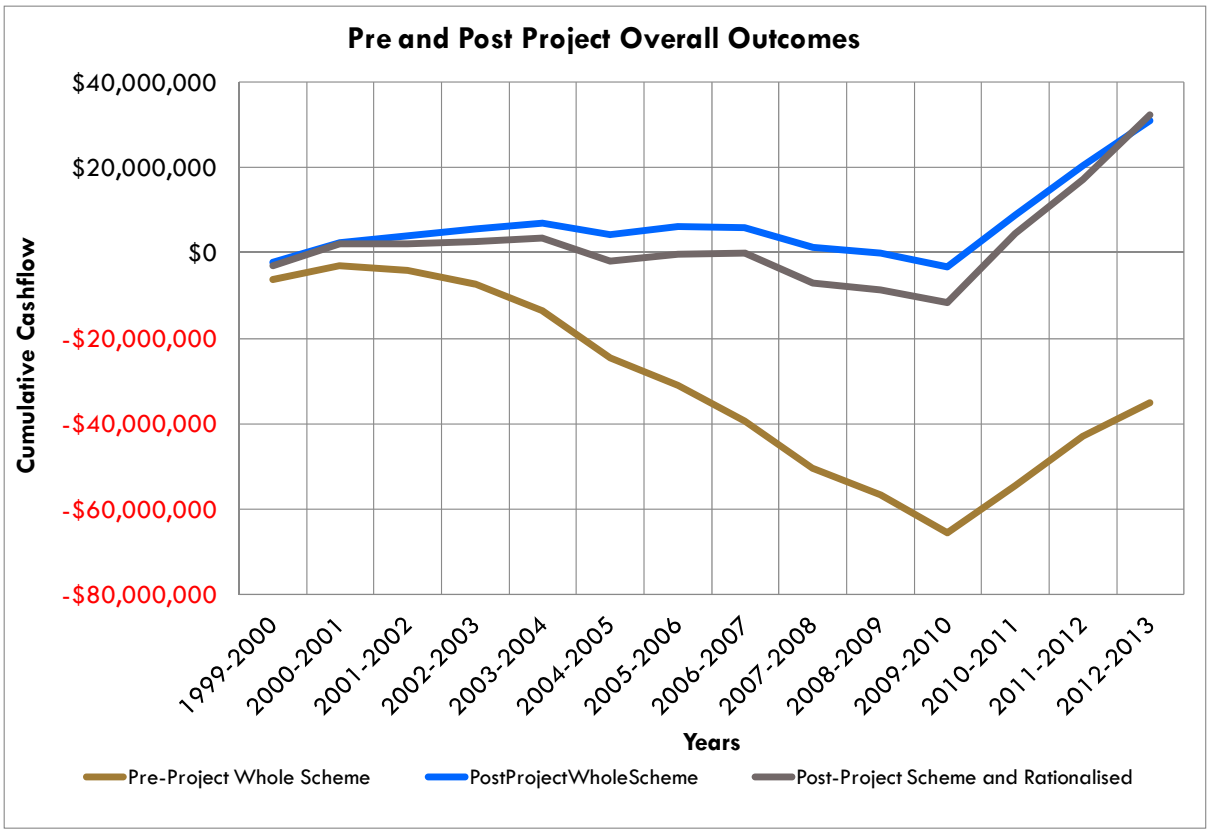

7.9 Improved sustainability of irrigation communities

Prior to the Modernisation Project, the Scheme members were facing declining productivity, profitability and equity owing to shortages in water availability and climate change, placing pressure on the viability of the Scheme. In turn, this increased pressure on the local community, which had already suffered a marked decline in population between 2001 and 2006 due to drought.[2]

Agriculture accounts for 44% of the Warren Shire's gross production of $110 million and 47% of total employment.[2] Of this, cotton is the largest single economic activity in the Shire, accounting for 31% of gross output, 22% of value added, 19% of employment and 16% of household income.[2] It generates about $39.9 million in direct production, $13.2 million in value-add and $2.4 million in household income via 90 jobs.[2]

It is estimated the cotton industry also produces a flow-on economic value of $21.3 million in production, $11.3 million value-add and $5.2 million of household income via 95 jobs.[2] The flow-on effect reflects the large amount of services (e.g. ginning, consultants, farm contractors and spraying) that are purchased by cotton growers.[2] Combined, the cotton industry contributes about $93.3 million to the local economy and provides 185 jobs.[2]

Members of the Tenandra Scheme account for about 12% of cotton production in the Warren Shire. Following the Modernisation Project, it is estimated that total cotton production by the remaining members will only decrease by only one percent, despite a 45% reduction in the Scheme's General Security Water Entitlement.

With regular maintenance of earthworks and ongoing replacement of pumps, controls and infrastructure, the Modernisation Project extended the functional life of the Tenandra Scheme by at least 50 years.

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Hutchings, T., 2013. *Financial risk for dryland farms in south-eastern Australia.* Unpublished PhD Thesis. Charles Sturt University, Wagga Wagga, NSW Australia.

[2]Powell, R. & Chalmers, L. (2008). *The economic structure of the cotton regions and the economic impact of the cotton industry.* A report to the Cotton Catchment Communities CRC.

8.0 Key learnings

Some of the key learnings from the implementation of the Tenandra Scheme Modernisation Project were:

1. Adoption of technology and change. The Modernisation Project sought to replace 50-year-old practices and technology with contemporary practices and technology. The overall complexity of the design, construction methods and project management challenged the mindset of some Members and contractors, highlighting the need for effective communication and allowing sufficient time for review when undertaking a major works program (see below).

2. Allowance for approvals. There was no allowance for delays in NSW Government approvals in the project timelines, which delayed the project by 12 months. These delays meant there was pressure to commence channel and siphon construction as soon as possible once the necessary approvals were obtained. In turn, insufficient time was allocated for the certification, tendering, review and awarding of contracts, particularly when the government approvals involved significant changes to the channel and syphon design and thus forecast costs. By this time, several other tenders (e.g. pumps and power) had already been awarded.

3. Allowance for contingencies. The PIIOP application included a 20% contingency for construction sub-projects (approximately $3.5 million). This contingency was struck out by the Department during the funding approval process. This meant that some lower priority sub-projects (e.g. the clay-lining and reshaping of existing channels in the Bottom Scheme) were not undertaken in order to fund contingencies associated with high priority projects (e.g. new link channels and pumps). This decision may have minor impacts on the maximum water savings achievable.

4. Importance of effective communication. The concurrent design, certification and tendering of several sub-projects meant that the revised design and budget of the complete project was not presented to the Board before the start of channel construction. In effect, the Board was asked by the Project Manager to approve tender recommendations without a thorough understanding of each tender, its cost and impact on other sub-projects. Several members of the Board felt they lost ‘ownership’ of the project during its initial stages.

5. Importance of corporate governance. The Board could have exercised more due diligence when delegating responsibility for making critical design and tender decisions to its initial project management team. Some critical decisions were made with a heavy weighting on cost rather than the overarching objective of improving water use efficiency. For example, the revised and approved channel design did not incorporate key recommendations based on detailed geotechnical survey. Likewise, the successful tender for the channel construction had unrealistic timelines that caused significant cost over-runs.

6. Importance of effective project management. The channel and structures sub-project was broken into six sections, ranging from $400,000 to $1.6 million, with the intention of making it easier to source local and presumably more cost-effective contractors. Ultimately, the Board was managing six contractors and claims across six interdependent tenders. A single tender would have been easier to manage in terms of quality assurance and financial control.

7. Importance of effective on-site supervision. The initial Project Manager provided a framework for project management but a lack of on-site supervision of contractors. The resultant failure to ensure the implementation of timely testing using the correct sampling procedures resulted in several quality assurance problems, budget overruns and delays associated with the channel and siphon sub-projects.

Despite these problems, the Board is to be commended for implementing an extremely complex civil engineering project that has achieved new benchmarks in water delivery efficiency. The Board showed extreme resilience to address and resolve these observed problems. Ultimately, the project was completed with a comparatively small cost overrun of $571,919 representing about 1.5% of construction costs and 0.6% of total project costs.